An exploration of the interface between Grade 11 Engineering Graphics and Design Teachers' understanding of Assembly Drawing and their practice: A case study of the uThukela District, KwaZulu-Natal

Douglas Thembinkosi Sibusiso Sotsaka

210555976
Masters in Technology Education

Supervisors: Dr. A. Singh-Pillay

Mr. M.P. Moodley

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ABSTRACT

Engineering Graphics and Design (EGD) is the universal graphical means of communication in the engineering field. Assembly drawing (AD) is a quintessential part of the EGD curriculum. AD requires learner to use in spatial visualization skills when engaging in mental manipulation and rotation of objects and transform so as to 2D images into 3D images. Such skills are important for success in many fields of science and engineering. The matriculation examiners' and moderators' reports reflect that EGD learners encounter problem pertaining to visualization in learning of AD because current teaching of EGD occurs via static drawing and does not emphasise learners' visualization skills.

In response to the aforementioned issue raised by the matric examiners report this study seeks to explore the interface between Grade 11 EGD teachers' understanding of Assembly Drawing (AD) and their practice of AD as a case study in the uThukela district, KwaZulu-Natal. The study is guided by three research questions:

1. What are Grade 11 EGD teachers' understandings of AD?
2. What are Grade 11 EGD teachers' practices of AD?
3. Is there an interface between Grade 11 EGD teachers' understanding of AD and their practice of AD? If so, what is the nature of the interface

To address these questions a qualitative case study design approach is used. Data is generated through an open ended questionnaire, focus group interview, classroom observation of AD as well as pre- and post-observation interviews. Purposive and convenience sampling are used to identify the respondents for this study. Data collected is subjected to content and thematic analysis.

The findings indicate that Grade 11 EGD teachers have four core understanding of AD. These are putting components together, putting components to form a structure and draw it, putting mechanical parts to facilitate an understanding of how they all function and involves visual reasoning, thinking of graphical images of mechanical components manipulating them and then putting it onto a diagram according to specifications. With regard to their practice of AD, three themes emerge; namely, chalk and talk, lecture method and teacher demonstrations, as well as demonstrations with hands on activities or projects.

The juxtaposing and (re)assemblage of data from the first two research questions indicates that an interface does exist between Grade 11 EGD teachers' understanding of AD and their practice of AD. The analysis confirms that the nature of the interface is shaped and sculpted by factors such as teacher qualification, training received for implementation of the EGD CAPS curriculum, professional activities as well as support within the school structure. These teachers' understanding and practice of AD are a (re)presentation and an amalgamation of their SMK, their learning style(s), the training they received to teach EGD, as well as the professional activities they engage with in terms of EGD. The findings of this study result in a proposed professional development intervention programme for teachers of EGD within the uThukela District.

Key words: assembly drawing, engineering graphics design, interface, practice, understanding, teachers

DECLARATION

I hereby declare that “An exploration of the interface between Grade 11 Engineering Graphics and Design Teachers’ understanding of Assembly Drawing and their practice: A case study of the uThukela District, Kwa Zulu Natal” is my own work and that all the sources I have used or quoted, have been indicated and acknowledged by means of complete references.

Douglas Thembinkosi Sibusiso Sotsaka
December 2015
Student Number: 210555976
Signed: _____
Date: _____
Supervisors: Dr. A. Singh-Pillay
Signed: _____
Date: _____
:Mr. M. P. Moodley
Signed: _____
Date: _____

DEDICATION

This thesis is dedicated to my Mom, **Sibongile G. (MaMtima) Sotsaka** and my children**, Ovuyonke, Amkele and Ethaba** you keep me grounded and are my everything. Thank you for your unconditional love, patience, tolerance, support, motivation and allowing me the space to pursue my academic endeavours. I love you dearly.

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LIST OF ACRONYMS

2D	Two dimensional
3D	Three dimensional
AD	Assembly drawing
CAD	Computer Aided Drawing
CAPS	Curriculum Assessment Policy Statement
CK	Content knowledge
DBE	Department of Basic Education
EGD	Engineering Graphics and Design
FET	Further Education and Training
HEI	Higher Education Institution
KZN	KwaZulu Natal
NCS	National Curriculum Statement
NSC	National Senior Certificate
PCK	Pedagogical Content Knowledge
PDI	Professional Development Intervention
PK	Pedagogical Knowledge
PSVT	Purdue Spatial Visualization Test
SMK	Subject Matter Knowledge
TD	Technical Drawing

LIST OF TABLES

LIST OF FIGURES

LIST OF GRAPHS

TABLE OF CONTENTS

CHAPTER ONE

INTRODUCTION

1.1.Introduction and background

In South Africa, severe skills shortages have been identified in critical fields, such as engineering, (DoL, 2009, Joint Initiative on Priority Skills Acquisition (JIPSA), 2006). In numerous initiatives to address the national imperative, the Department of Education has been recognised as a driver in terms of access, throughput and articulation for the engineering sector (National Development Plan of South Africa (NDP) (2010-2030). However, the skills shortages is critical, despite five waves of school curriculum reform (C2005, OBE, RNSC, NCS, CAPS), and the government's efforts to increase output of the valuable skills by increasing the education budget. Instead, many see the South African education and training system as the main contributor to the national skills crisis (Kraak, 2008).

Looking more closely at engineering, selection for access to higher education programmes is almost exclusively based on an applicant's final matriculation results in Mathematics, Physical Sciences and Engineering Graphics and Design (EGD). Up to now the major challenge in educating prospective professional engineering students is the poor quality of school teaching in these subjects, leading to a small number of learners passing matric with the required symbols. It has been specifically stated that high-quality engineering students come from good schools with good quality teachers in these subjects (Cheng, 2006). In particular, successful implementation of the EGD curriculum is dependent on teachers having a solidly established personal construct of EGD, equivalent to that of the curriculum (Tholo, Monobe, & Lumadi, 2011). Put simply, this means that the responsibility for developing and nurturing top quality engineering candidates rests with schools and subjects teachers.

Whilst for learners embarking on engineering studies the values and skills gained in Mathematics and Physical Sciences have been well documented, it is worth noting that EGD also provides learners with a valuable bridge between high school and university engineering studies. In particular, EGD techniques involve mathematical and analytical reasoning as well as spatial

visualization skills, which are specifically aligned to further education in engineering. In this regard, many engineering students from different universities and colleges have stated that EGD helped them achieve good results in their first year of engineering (Cheng, 2006).

Besides specific skills that may be transferred into their tertiary studies, in EGD learners also gain greater understanding of the work entailed in engineering. They learn to construct engineering drawings, which are an important mean of communication between engineers, technicians and professionals involved in design and production. As such, engineering drawings are used to describe products, and give instructions about their manufacture, assembly and operation. These drawings are clear, complete and accurate, so as to prevent expensive and/or dangerous mistakes for manufacturers, producers or customers. Furthermore, EGD incorporates aspects of civil, electrical and mechanical engineering and hence makes learners aware of the different fields of engineering and their respective rules and regulations.

1.2.Rationale

For ten years up to 2012 I was a Subject Advisor for Civil Technology and Engineering Graphics and Design in the KwaZulu-Natal (KZN) Provincial Department of Education. My duties entailed providing support for teachers of Engineering Graphics and Design (EGD) in the Further Education and Training band. I also monitored and moderated marking of examination scripts for the National Senior Certificate (NSC) (Grade 12 Matriculation). In the NSC examinations for EGD, learners write two papers. When moderating, I observed that many EGD candidates performed poorly in the paper covering Mechanical Drawing, especially in the section on Assembly Drawing (AD). Assembly Drawing is an important aspect of EGD, as is evident by the weighting of 20 % that it is given in the NSC examination. In an assembly drawing, learners are given representations of up to seven components, which must then be drawn correctly, assembled in third angle projection, reflecting the front view, top view and side view. When drawing the assembly, learners are also expected to apply the relevant Codes of Practice for Engineering Drawing as given in SABS (1993) and SANS (2011). I have noted that in final examinations many candidates did not even attempt the question pertaining to Assembly Drawing, resulting in extremely low marks for EGD. Furthermore, although the majority of EGD candidates had attempted the Assembly Drawing question, they lost marks by answering the

question incorrectly or not finishing the drawing. Such observations, highlighting areas of learners' weakness and/or misconceptions pertaining to AD, have been recorded repeatedly in examiners' and moderators' reports on the EGD National Senior Certificate examinations (DBE, 2012; 2013, 2014). For example: "Some candidates have difficulty interpreting, and or understanding the projection symbol for third angle and confusion between first and third angle orthographic projection understanding of machining symbols, learners should be exposed to the SANS 10111 code of practice" (DBE, 2011 p.4). Each year, the examiners' and moderators' report are sent to all relevant schools, so that both the principal and EGD teacher have access to it and can use the suggestions to improve teaching and learning. Furthermore, the EGD Subject Advisors discuss these reports with EGD teachers during their monitoring and school visits. What amazes me is that despite these efforts to improve learners' performance in EGD, the identified areas of weakness and misconception still persist year on year among EGD learners. It would seem that EGD teachers take no heed of the examiners' and moderators' report when planning and aligning their teaching, and remain oblivious to the learners' difficulties mentioned therein, or are unable to address them. This raises pertinent questions in terms of EGD teachers' competencies. My observation of the persistently poor performance of Grade 12 learners in Assembly Drawing motivated me to explore EGD teachers' own understanding of AD and the way they teach it. Specifically I wished to establish if an interface exists between teachers' understanding of AD and their teaching practice for AD and then to describe the nature of the interface.

My personal concerns regarding teacher practice in AD have been echoed elsewhere. In the previous section I have already noted a national concern about the challenges that engineering undergraduates experience during their enrollment in engineering science at tertiary institutions (DBE, 2011). Specifically, EGD is construed as a means of developing an interest in engineering among learners and encouraging them to consider it as a career. Moreover, the EGD curriculum is also intended to foster learners' elementary problem solving skills such as iteration, testing of alternative solutions, and evaluation of data to guide decisions (Benenson, 2001) and to motivate them to learn mathematics and science concepts through illustration of relevant applications (Engstrom, 2001; Wicklein, 2003, Petroski, 2003). Therefore, studying EGD in high school has several cognitive advantages for learners, including developing engineering "habits of mind", as well as skills in problem-solving and systems-thinking. Nevertheless it is well known that the

implementation of any curriculum hinges on teachers. In this regard, Jayasree (2003) attributed the problem that EGD students encountered with visualization in their subject to current methods of teaching and learning of EGD; that is via static drawing instead of hands on activities. Such traditional teaching methods and approaches are not enhancing the students' visualization skills (Widad, Rio & Lee, 2006). Is the teachers' traditional practice perhaps due to their own deficiencies in understanding AD? It is, therefore, crucial to determine if there is indeed an interface between EGD teachers' understanding of AD and their practice when teaching the material and then to describe the nature of this interface.

1.3.Purpose of this study

The purpose of this study is to:

- Explore Grade 11 EGD teachers' understanding of AD;
- Explore Grade 11 teachers' practice in teaching AD;
- Explore if there is an interface between Grade 11 EGD teachers' understanding of AD and their teaching practice for AD; and
- Describe the nature of the interface.

The research questions that guide this study are:

1. What are Grade 11 EGD teachers' understandings of AD?
2. What are Grade 11 EGD teachers' practices of AD?
3. Is there an interface between Grade 11 EGD teachers' understanding of AD and their practice of AD? If so, what is the nature of the interface?

1.4.Significance of this study

This study will be beneficial to EGD subject advisors and curriculum developers in that it will provide a deeper insight into teachers' understanding of AD and their practice with regard to AD. It could also inform the pre-service curriculum for prospective EGD teachers. The findings from this study could provide clearer direction for the support and professional development provided to practicing teachers by subject advisors in terms of AD. Ideally, the findings of this study will help EGD teachers to engage in reflective practice with respect to their engagement with AD and

this could contribute to a more nuanced practice, thereby assisting future undergraduate engineering students to cope better with the challenges they encounter in their tertiary studies.

1.5.Limitations of this study

This study uses a case study method and selects the uThukela District as its geographical area. The 11 schools within the uThukela District that offer EGD form the sample of the study. Case study methods may be criticised because the results cannot be generalized. Nonetheless, Flyvbjerg (2006) highlights single cases of experiments by, or experiences of, Galileo, Newton, Einstein, Bohr, Darwin, Marx and Freud to show that both human and natural sciences could be advanced by a single case. In addition, Erickson (1986) argues that because the general lies in the particular, what we learn in a particular case can be transferred to similar situations. Consequently, despite its limitations, a case study can further our insight into similar situations. In this study, the case study method allows for an in-depth and detailed study of Grade 11 EGD teachers' understanding of AD and their practice of AD, and so provides rich thick descriptions of the case (Shuttleworth, 2008).

1.6.Clarification of terms

To avoid any confusion, certain key terms need to be clarified for the purpose of this study.

Teachers' understanding represents their personal subject matter knowledge (SMK) of AD. It is closely related to training they received to become an EGD teacher

Teachers' practice is a procedure or way of doing something; in this case teaching AD, which is invariably linked to pedagogical content knowledge (PCK), school ecology and professional communities.

Interface is construed as the point where there is convergence of and/or divergence between Grade 11 EGD teachers' understanding of AD and their practice of AD (Singh-Pillay, 2010).

1.7.Overview of the remaining chapters in the dissertation

This dissertation is organized into five chapters. The present chapter has set the stage and motivation for the study described in the dissertation. The aims and research questions inform the focus of the next chapter. Chapter 2 will focus on a review of literature relevant to the research questions, so as to provide background to the study. Then the theoretical framework is discussed, which will be used to underpin the analysis and arguments put forward in addressing the research questions.

Chapter 3 sets the stage for the research methodology used to answer the research questions. The chapter provides reasons for the choice of research method and design, and methods of data analysis. The development of materials, and processes undertaken to improve the different data collection tools and hence the reliability of results are discussed in depth. Ethical aspects of the research are coincided.

The fourth chapter covers data analysis. Field data collected according to the research methodology is analyzed against the theoretical framework, in order to answer the research questions posed in this study. The final chapter consists of a critical discussion on key findings of the research.

1.8.Conclusion

In this chapter it has been shown that, despite various government initiatives to address the South African engineering skills shortage, learners still struggle to give adequate answer examination questions for the Assembly Drawing aspect of EGD. There are, thus, unanswered questions relating to teachers' understanding and teachers' practice in this topic, and the interface between them. Findings from this, albeit limited, case study focused on EGD teachers in 11 schools could be useful in directing the support that such teachers need in order to improve the competencies of learners in EGD. The three research questions will be addressed in the remaining four chapters of this dissertation.

Chapter Two

Literature review

2.1. Introduction

The previous chapter highlighted observations on learners' poor performance in Engineering Graphics and Design (EGD), particularly in assembly drawing (AD). Most South African EGD learners perform poorly on national examinations in EGD (Fleisch, 2007). There is a range of complex reasons for this underachievement. One set of reasons occurs at the macro-societal level, where poverty, malnutrition, unemployment and high HIV/AIDS rates in many communities have a very strong correlation with poor learner achievement (Fleisch, 2007). The second set of reasons is located at the school level. Concerning this level, Soudien (2007) argues the legacy of apartheid still plays a major role in the ineffectiveness of the education system. To be specific, Taylor (2009) reports that many schools are not ordered organisations where teachers are present and time is used effectively. Furthermore, the conditions in which many teachers work simply do not support quality learning (Shalem and Hoadley, 2007). The third set of reasons is located at the classroom level, where research shows that many teachers do not induct their learners systematically into school knowledge (Hoadley, 2007). These factors impinge EGD learner entry to and success in tertiary engineering studies. Bearing the aforementioned contextual challenges in mind and the three research questions posed in this study concerning teachers' understanding and practice of AD, and their interface, this chapter presents a review of literature and the conceptual framework that are pertinent to this study.

Four aspects of the literature are surveyed. I first focus on the shift from technical drawing (TD) to EGD so as to highlight the change in context, assessment and methodology for the subject. To this end, the Curriculum Assessment Policy Statement for EGD is surveyed to illuminate the content of the EGD school curriculum, and highlight the demands entailed in assembly drawing. Then some literature reflecting scholars' views on appropriate teaching practice to promote learning in EGD/TD is examined. This aspect identifies appropriate strategies to address the areas of weaknesses discussed in the annual NSC EGD examiners' and moderators' reports. Literature pertaining to teaching practice that promotes learning in EGD furthermore unveils the

embedded relationship between teachers' understanding of AD and its influence on their practice of AD. Fourth the conceptual framework that underpins this study is elucidated.

2.2. The Shift from Technical Drawing to EGD

The subject Engineering Graphics and Design has evolved from the subject previously known as Technical Drawing (TD). Although TD was in the curriculum for a few non-technical high schools, it was mainly offered at technical high schools, over five years (Standards 6 to 10, grades 8 to 12 or Forms 1 to 5). The purpose of the subject was to prepare learners to work as tradesmen, artisans, technicians or engineers (DBE, 2011). To this end, TD was frequently offered in a school course along with other technical subjects such as bricklaying and plastering, woodworking, welding or metalwork. The restructuring of the post-apartheid education landscape in South Africa led to the transition from TD to EGD. This has been more than a name change; instead there has been a shift in emphasis in the subject context, assessment and methodology, as reflected in Table 1 below.

Table 1: Shift in emphasis from TD to EGD

NATED Report 550		**NCS-CAPS**
Technical Drawing		**Engineering Graphics and Design**
Context	Geometrical and mechanical	Civil, electrical and mechanical
	Instrument drawing with some freehand drawing	Freehand drawing, instrument drawing and computer aided draughting
Assessment	Examination orientated	School based assessment and examinations
	First angle projection	First and third angle projection
Methodology	Unrelated to industry and needs of country	Relates to industry and the needs of the country
	Limited links to other subjects	Encourages links with other subjects
	Environmental issues and human rights not addressed	Strong emphasis on environmental issues, HIV/Aids and human rights
	Little or no creative thinking	Emphasizes critical and creative thinking skills

Source: DBE, 2011

From the table above, the shift of focus concerning the context, assessment and methodology from TD to EGD becomes evident. It can be seen that, among other changes, the contexts used in the subject have changed. In this regard, Technical Drawing used mechanical engineering and geometrical drawing to develop three-dimensional perception and to teach projection methods. Now in Engineering Graphics and Design knowledge, skills and values are contextualised in Civil, Electrical and Mechanical Technology as relevant in South Africa. Furthermore, the design process is now used as an organizing tool (DBE2011). Most notably, EGD now places greater emphasis on critical and creative thinking.

According to DBE (2011) the aim of EGD is to develop the learner's ability to address problems and exploit opportunities in a creative and innovative way. In EGD, learners are equipped to apply cognitive skills, such as critical and creative thinking, analysis, synthesis and logic to practical, real life design and engineering problems. This subject equips learners with the skills, knowledge and values to function in an engineering and design environment. It also stimulates an innovative and entrepreneurial spirit and enhances learners' technological literacy. The learner will thus be equipped to appreciate the interaction between people's values, society, the environment, human rights and technology. Therefore EGD should equip learners with the basic occupational competences required by engineering and technology disciplines.

Two aims of EGD, according to Prieto & Velasco, (2002), are enhancing learners' spatial perception and visualization. Sternberg (year) explains spatial perception as the process by which we sense something; for instance, its size, shape, or orientation. This enables one to discover the basic concepts of shape through self-investigation (Prieto & Velasco, 2002). Steernberg defines visualization as the ability to work mentally with an object, in order to rotate it or imagine it from different views, angel, or visualize hidden parts. Similarly, Delacour (2004, p. 11) explains visualization as the process used to mentally rotate two- and three-dimensional objects that are pictorially represented. This ability to mentally manipulate objects and their parts in 2D and 3D space requires spatial ability (Kovac, 1989). It is therefore apparent that visualization and perception work hand in hand, and studying EGD enhances them both, as explained below (Prieto & Velasco, 2002).

• *Enhanced perception:* In EGD, one needs to form a mental image of the object represented, guided by the various line-types shown in a drawing. This depends on students knowing how to

interpret different types of line. The perception process must be applied before one can mentally twist or turn the drawing in order to imagine how the object would be cut or sectioned.

• *To enhance visualization*: This means that before the a technical operator can make or machine an object from the drawing placed in front of him, he must be able to imagine the object from all angles. Visualisation requires a comprehensive understanding and good reading of line work in order to describe the underlying components in a drawing.

These two skills are integrated in EGD where objects may be represented in two or three dimensions, 2D or 3D. A 2D drawing shows only two sides of the object, whereas in 3D an object drawn in a manner that three of its sides are visible. This means that for any attempt at a given drawing, one needs the skill to visualize shapes and work out what the object looks like when rotated, both in two- and three dimensions. Therefore the relationship of the two terminologies above to assembly drawing is that an assembly drawing is asked for in either two- or three-dimensional format or one to be able to work out the requirements of a drawing, perception and visualization are key operations

2.2.1. Content of EDG School Curriculum

The Curriculum and Assessment Policy Statement (CAPS) for EGD in Further Education and Training Phase (FET) Grade 10–12 provides internationally acknowledged principles that have both academic and technical applications (DBE, 2011). The emphasis in EGD is on teaching specific basic background knowledge and various drawing techniques and skills that the EGD learners should use to interpret and produce drawings within three contexts (Mechanical, Civil and Electrical) of manufacturing, engineering and technology. The main topics covered in EGD are as follows: general drawing principles for all technological drawings, freehand drawing, first- and third-angle orthographic projects, descriptive and solid geometry, mechanical working drawing, civil working drawing, isometric drawing, perspective drawing, electrical diagrams, interpenetrations and developments, loci of helixes, cams and mechanisms, design process and CAD (Computer-Aided Drawing/Design) (DBE, 2011). By foregrounding these concepts, EGD aims to teach graphical drawings as a means of communication in the world of technology, to solve technology problems graphically, using drawing instruments, and use content and concepts

for the application of the design process in the context of Mechanical Technology, Civil Technology or Electrical Technology.

By foregrounding these concepts, EGD aims to teach graphical drawings as a means of communication in the world of technology. In other words, learners solve technology problems graphically, using drawing instruments or CAD, and apply the design process, using appropriate content and concepts, in the context of Mechanical, Civil or Electrical Technology.

In the FET phase, the EGD examination comprises of two three-hour papers with topic weighting (as approximate percentages) reflected in Table 2 below.

Table 2: Structure of Grade 12 examination papers

Grade 12 Examination Papers					
Paper 1: first-angle orthographic projection			Paper 2: third-angle orthographic projection		
Question			Question		
1	Civil analytical	15	1	WHAT TOPIC?	15
2	Interpenetration and development and/or development of a transition piece and/or solid geometry	20	2	Loci of a helix and/or loci of cam and/or loci of a point(s) of a mechanism	20
3	2-point perspective drawing	20	3	Isometric drawing	20
4	Civil working drawing including electricity features	45	4	Mechanical assembly	45

Source: DBE, 2011, p. 40.

From the table above it can be seen that Civil working drawing including electricity features and AD are the most important topic, with assessment in each of them contributing nearly half of the respective papers, whereas assessments in other topics each contribute less than a quarter of each paper.

A closer examination of the CAPS EGD content by Biggs (2003) verifies constructive alignment; in other words there is coherence between learning outcomes, content, teaching strategies to be used and assessment-learning activities. Specifically, the content is aligned in

terms of sequencing of topics, progression of conceptual development or continuity and scope. Ornstein and Hunkins (2009) give explanation of these terms, as follows. Sequencing relates to the order in which specific parts of the curriculum should be learned with respect to other parts. Scope refers to the breadth and depth of content in a curriculum, and is associated with horizontal curriculum design while continuity is described as the vertical integration of the curriculum design. Continuity in a curriculum provides learners with opportunities to revisit knowledge and skills in more depth as they progress through the years. Continuity can relate to subject matter or to other skills such as team-working and problem-solving. (Biggs, 2003) Assessment procedures should reflect this developmental approach, by requiring students to achieve higher-order cognitive competencies as they mature. Alternatively, assessments could require learners to build higher levels of responsibility or autonomy in a skill, through peer- or self-assessment.

Table 3 below reflects the scope, sequencing of topics and continuity pertaining to mechanical drawing (Assembly drawing is a component of mechanical drawing).

Table 3: Scope and sequencing of topics pertaining to mechanical drawing

Mechanical Drawings which develop knowledge, understanding and skills		
Grade 10	Grade11	Grade12
1st and 3rd angle **orthographic** projection **Pictorial** Isometric, oblique (single components such as individual parts of a machine, castings) Simple **assemblies** **Fasteners** (e.g. nut, bolt, washer, pins)	1st and 3rd angle **orthographic** projection **Assemblies** & **detail** drawings **Pictorial** Isometric (single **Components** such as individual parts of a machine, castings) **Fasteners** (e.g. spacer, keys, locknuts) **Loci**: helix (single start), Cam (roller & wedge follower) **Developments**. (e.g. containers, hoppers, basic transition pieces, e.g. square to square, rectangle to square, container covers/lids)- (implies true shape, true lengths as well as interpenetration lines)	1st and 3rd angle **orthographic** projection **Assemblies** & **detail** drawings **Components** of steel structures (e.g. beams, bolts, gussets, welding symbols, toe) **Pictorial** Isometric (single components such as individual parts of a machine, castings) **Fasteners** (e.g. spacer, keys, locknuts and extend) **Developments** to include seams and joints (e.g. containers, hoppers, complete transition pieces, e.g. square to round, rectangle to round, container covers/lids)- (implies true shape, true lengths as well as interpenetration lines) **Loci** of points on the components of mechanisms.

Source: DBE, 2011

The table above shows scope by revealing the depth of the content pertaining to mechanical drawing. Sequencing of topics is noted in the order in which the topics are organized. While continuity is reflected in the way that topics provides learners with opportunities to revisit knowledge and skills in more depth as they progress through the years.

2.2.2. What is Assembly Drawing?

As mentioned earlier, AD is a component of mechanical drawing. According to Kabouridis (2010) fundamental skills required for all aspects of mechanical drawing as the ability to perceive and visualise parts, and to interpret different views of an object that is represented in the drawing. For learners to engage with all mechanical drawing they need to think and reason visually. In other words learners must be able to study the given views of an object and to form a mental image of it. Simply put, they must visualise its three-dimensional shape (Giesecke, Mitchell, Spencer, Hill, Dygdon & Novak, 2002). Beyond these core skills for interpreting mechanical drawings, those for AD are more sepific.

According to Narayana, Kannaiah, Reddy and Venkata (2006), AD is the presentation of various parts of a machine in their working positions, and these drawings are classified as design assembly drawings, working assembly drawings, sub-assembly drawings, or installation assembly. Narayana et al. (2006) posit that AD entails spatial visualisation ability, visualisation skills and drawing skills, because it entails mental manipulation of objects and their parts in 2D and 3D space, which Kovac (1989) terms spatial ability (see Section 2.2.1). An assembly drawing consists of a numbers of different parts or components of a machine or system with a number of dimensions for clear interpretation. When these parts are interlocked, they form a complete functional machine. Van Leeuwenn and du Plooy (2011) are more specific. They defined AD as the combination of any two or more individual components, with all those multiple-component devices making up the individually designed parts that fit together to form a functional unit. From this they contend that a drawing showing only a few parts of a larger assembly should be referred to as a sub-assembly.

In South Africa, AD is an important aspect of Mechanical Drawing (paper two). As mentioned earlier in section 2.2.1. and reflected above in table 3 there is sequential progression of the content and skills associated with AD to scaffold learners' learning and application from Grades 10 to 12 in the EGD CAPS document.

2.3. Scholars views on teaching practice that promotes learning in EGD/TD

Like any language, engineering drawing as a means of communication consists of technical rules or drawing conventions (Olkun, 2003). In engineering lines and symbols is a more effective means of communicating thoughts than verbal descriptions. Therefore all people related to the technical industry should be capable of reading or interpreting a drawing accurately. Thus there is a non-negotiable need to learn how to read and write a drawing. So like language one needs to know and use the conventions and rules (Olkun, 2003). In order to apply the rules, certain skills are needed, especially spatial perception and visualization (as discussed in section 2.2.1) as well as spatial ability. Olkun (2003) maintained that spatial thinking is essential for scientific thought as it is used to represent and manipulate information in learning and problem solving (Clements & Battista, 1992). In support, Kovac (1989) pointed out that spatial ability is the mental manipulation of objects and their parts in 2D and 3D space and can be improved through appropriate activities. In addition, Kabouridis (2010) maintains that for EGD learners, visualisation skills are very important for understanding fundamental concepts of drawing. Therefore the curriculum should include and emphasise such skills and these skills should be foregrounded in teaching.

Many learners have difficulty in understanding or comprehending the graphic representation of three-dimensional objects. According to Perez, and Serrano (2012), the high failure rate of school learners in their exit examinations in EGD is due to the difficulty of understanding the mechanisms related to the representation of 3D objects in 2D. This means that learners have not sufficiently developed their spatial ability. Okolie (2014) found that this high failure rate, is associated with traditional teaching methods; in particular missing connections between the drawing and the design of the product itself.

So in order to teach these skills, teachers should adopt the practices outlined below and the curriculum should include computer applications. Branoff, Hartman and Wiebe (2003) contend that EDG teachers must expose learners to hands-on experience of drafting techniques, drafting standards and conventions. In order to do this, the curriculum should expose learners to practical engineering graphics skills and knowledge about how various design components and systems relate and work together on any given project. These competencies develop only by engaging learners in activities that target the f problem-solving skills and the ability to think, see, create and model 3D visual images in space or on paper from 2D blueprints using a variety of media. The implication for teaching is that these skills cannot be developed "by rote learning or memorization". In addition, learners should be exposed to emerging trends in technical graphics, developments in industrial technologies and advancement in computer technology. Simply put, this means that EGD learners have to be trained in developing spatially-related problem-solving abilities (Kabouridis, 2010). One major limitation of traditional instruction is the problem of presenting three-dimensional spatial information (3-D) in a two-dimensional format (2-D).

Felder and Silverman (1988) assert that learning styles of engineering students and teaching styles of engineering professors are incompatible in several respects. Put simply this means that tuition or teaching style should match the learning style of students. They point out that learners learn in many different ways, including by seeing and hearing; reflecting and acting; reasoning logically and intuitively; memorizing and visualizing; drawing analogies and building mathematical models. The chosen teaching method or didactic approach may also impact on learners' learning styles and so their understanding of content. For many different reasons, some teachers apply, or prefer, a certain method for a particular topic. The view that learning occurs in a structured education setting and is a merely a two-step process that involves the reception and processing of information is problematic. Felder and Silverman (1988) described these two steps as follows: processing as memorising or inductive or deductive reasoning, reflecting as action, and introspection or interaction with others. They based this on the finding that many engineering students' learning styles are visual, sensing, inductive, and active whereas most engineering education is auditory, abstract (intuitive), deductive, passive and sequential. So, in order to avoid professorial frustration, and poor student performance with the subsequent loss to

society of many potentially excellent engineers, they recommend that appropriate teaching styles should be employed for engineering students.

ICT may provide a solution for teaching fundamental visual skills to mechanical engineering students. According to Zuo, Feng and Chen (2003) Chinese teaching content and methods have remained static. Traditionally twice as many notional hours were allowed for teaching as for practice exercises. Integrating teaching and practice gave more effective use of staff and better student achievement. Zuo, Feng and Chen (2003) implemented Engineering Graphics education reform for a period of more than six years in Chinese schools. Their objective was to capacitate and improve teaching ability of teachers in Engineering Graphics Drawing and improve students' imagination and ability of design. They further stated that for many years in China effective teaching of Engineering Drawing had been challenged by teaching content and methods having remained static. Most universities in China mixed Descriptive Geometry and Engineering Drawing in one course. There were 40-80 hours allowed for teaching, but only 20-40 hours for exercises. In their study, they changed the course system and combined the two teaching methods into three aspects, namely, drawing combination, manual drawing combined with computer drawing, and class teaching combined with interactive studying in network. They found that by these changes large numbers of students were taught by one teacher in a shorter period of time, and with better results. Zuo et al. (2003) thus recommend the use of multimedia Computer Aided Drawing and web-based education software. They point out that multimedia software is one means of modernizing technical education. They also emphasised that with modern education techniques, Engineering Drawing was no longer dull and dry. The subject became more attractive and accessible than before. In other words, the use of computers in drawing made it more user friendly for students.

Further to the work of Zuo et al. (2003), Kabouridis (2010) noted the poor performance mechanical engineering students and has designed a learning environment based on ICT. The aim of this new environment is to tackle the given drawing problem by modification of course design, with teaching methods more compatible with students' learning styles, saves class time and makes the subject more accessible to a large number of students. The researchers pointed out

that each textbook that they had developed also had a multimedia CD attached. Whilst this is an excellent ideal it should be noted that not all users might have computers.

Branoff and Dobelis (2012) conducted a study in North Carolina State University, to measure the students' ability to model objects from assembly drawing. These results revealed that over the last 30 years, engineering graphics content in engineering programmes has changed to meet the needs of industry and also to meet changes in accreditation requirements. Engineering graphic courses were strengthened and curricula were modified. Solid modeling and other CAD tools have replaced descriptive geometry and other engineering graphics topics. Livshits and Sandler (1999) agreed that computerisation within engineering programmes was necessary to provide students with current skills, but again it comes at the cost of deficiencies in other areas. A small scale study of high school students in assembly drawing indicates that after class tuition less than half were able to successfully model seven parts in an assembly during a 110-minute class (Livshits and Sandler, 1999). In the study, there was a wide range of student scores indicating difficulties with reading the engineering drawing. Although it was possible that the students had not taken the task seriously, it did indicate that they had not been able to visualize the individual parts within the context of an assembly; thus posing a question as to whether or not the teaching and learning mode had been appropriate. Uçan, Ercan, and Ercan (2012) maintained that design is the common denominator of engineering and is the repeated/iterative process through which an engineer is able to optimally covert available resources into devices or systems that satisfy the consumer needs to which the design is addressed. From their research, the findings indicated that drawing forms the core of all other engineering courses. Technical drawing and design must be taught in all other engineering departments. All students must be introduced to computer usage to develop their visualization skills and be capacitated to fit in the world of industry.

From the above studies and discussion it can be gathered that EGD teachers need certain knowledge. Having reviewed the perspective of various scholars on teaching practice that promotes learning in EGD significant questions exists around the requisite subject matter content knowledge required of EGD teachers. For example can an EGD teacher who lacks or is not professionally trained to teach EGD teach lessons that are valid in content and context?

EDG teachers need to be familiar and comfortable with the EGD content and context as well as the pedagogical content knowledge (PCK) in EGD to effectively engage with the engineering sciences, design process as well as the necessary mathematical and analytical reasoning associated with Assembly Drawing. Only then will they be able to develop technological literacy in learners, encourage learners to pursue STEM fields of study at school and higher education institutions, and equip students better for further study in STEM fields at higher education institutions. This means that the essence of teachers' work is to organise systematic learning. According to Marrow (2007, p. 107) 'systematic learning' is not about transmitting bits of information, but is a practice that "centres around the design of learning programmes that foster the gradual development of competences that cannot be learned in an instant". I analyse the literature on teacher knowledge in order to present my conceptual framework of what kind of teacher knowledge is needed in order to engage with the professional practice of organising systematic learning in Assembly drawing.

2.4. What do EGD teachers need to know to engage in their practice?

Having shown in the previous section that specific teaching practices lend themselves to effectively developing the visual skills needed for success in EGD, I now turn to the specific knowledge that teachers need in order to engage in such practice. To answer this question I turn to Shulman (1986).

Shulman (1986) was the first scholar to describe a knowledge base for teachers or to answer the question: what is it that teachers need to know? Jones and Straker (2006) describe Shulman's model of teacher knowledge as comprising four domains. These are: content knowledge (the knowledge of the subject content that needs to be taught); general pedagogical knowledge (knowledge of different teaching strategies, classroom management strategies, assessment strategies etc.); context knowledge (knowing about the background of the learners, knowing the organisational culture of the school etc.) and pedagogical content knowledge (PCK is understood as the knowledge used when a teacher re-contextualises her content knowledge so that it can be understood by the learner). In a similar vein, Zeidler (2002) argues that within science education reform, the three anchoring points have been teachers' subject matter knowledge (SMK),

pedagogical knowledge (PK) and pedagogical content knowledge (PCK). These are three of Shulman's four domains.

In terms of *content knowledge (CK)*, I argue that what is really important for EGD teachers is a deep and integrated understanding of the fundamental concepts pertaining to Assembly Drawing, rather a huge collection of facts relating to the subject. It is this understanding of fundamental concepts and how these concepts are related and organised that enables teachers to use their subject matter knowledge for teaching. Adler, Slonimsky and Reed (2002) argue that while teachers' broad and deep knowledge of the subject is necessary it is not sufficient for effective teaching.

General pedagogical knowledge is also complex as it includes knowledge of classroom organisation and management, different teaching strategies or methods, assessment strategies as well as understanding classroom communication and discourses (Morine-Dershimer & Kent, 1999). These scholars suggest that there is interplay between general pedagogical knowledge and personal pedagogical knowledge which is "fueled by personal beliefs and personal practical experience" (p.22).

Shulman described *pedagogical content knowledge (PCK)* as "the blending of content and pedagogy into an understanding of how particular topics, problems or issues are organised, represented and adapted to the diverse interests and abilities of learners, and presented for instruction" (Shulman, 1986, p.127). This means that Shulman understood PCK to be the knowledge that a teacher uses to transform or recontextualise his/her content knowledge so that it can be understood by the particular learners in his/her classroom. Over the past two decades there has been a great deal of research interest in Shulman's concept of PCK. Turner-Bisset (1999) built on Shulman's model by suggesting that all forms of teacher knowledge (such as content knowledge, pedagogical knowledge) are sets within the larger set of PCK. However according to Ellis (2009), Turner- Bisset seems to have fragmented the concept rather than strengthened it and so this does not enhance our understanding of PCK. Hashweh (2008) suggests that PCK should be viewed as a collection of teacher pedagogical constructions. In a review of the literature on competent beginning teaching, Reynolds (1992) labels PCK as

'content-specific pedagogy' which she places at the overlap of three kinds of teacher understanding: general subjects/liberal arts, general principles of teaching and learning, and subject content knowledge. While the literature surveyed thus far shows that PCK may be considered to be a contested term, with no accepted clarity as to its exact meaning, there is general agreement that teachers need more than deep knowledge of their discipline, and general pedagogy. Adler, Slonimsky and Reed (2002) argue that teachers' subject knowledge needs to be transformed into "sequenced, graded and developmental/progressive tasks for learners, learning and assessment" (p.139). In order to do this, teachers need pedagogic knowledge and knowledge of the curriculum in their subject area. They also need to know how learners come to know a specific subject and how the context in which they are teaching shapes the teaching and learning of their subject. Adler et al. (2002) describe this integration of disciplinary and pedagogical knowledge as 'conceptual knowledge-in-practice'. This knowledge-in-practice is explicitly linked to teaching a specific subject, and should not be seen as a generic knowledge (Rusznyak, 2010).

Thus from Shulman's work and the work of other scholars cited above it is obvious that teachers should draw on deep disciplinary knowledge, general and personal pedagogical knowledge and pedagogical content knowledge (the knowledge that integrates the first two types, and is discipline specific) for their practice.

According to Jones and Straker (2006), Shulman's knowledge domains are largely propositional, in that he does not engage with teachers' practical or professional knowledge and ignores the inter-relationship between theory and practice.

Types of knowledge: practical and propositional

This shift the attention away from Shulman's categories on teacher knowledge, resonates back to more generic ways of categorizing knowledge domains, as have been explored by curriculum theorists such as Schwab (1978). In this regard, Ryle (1971) discusses the ideas of knowing 'how' and knowing 'what'. In a similar way, Knight (2002) distinguishes knowledge as being either practical or propositional. P*rocedural or practical* knowledge comprises both behavioural and cognitive skills, whereas *declarative, propositional or higher-order* knowledge includes

facts, abstract knowledge of ideas and principles, and is mainly about sense-making and meaning. Practical knowledge is primarily about learning to do (Knight 2002).

Gamble (2009) describes knowing how as 'procedural knowledge' and knowing what as 'principled knowledge'. Another way of describing propositional knowledge is 'codified' knowledge while practical knowledge can also be known as 'context-specific knowledge' (Wilson and Demetriou, 2007). This practical knowledge is difficult to make explicit or to represent through text because it is largely acquired informally through participation in social activities. Wilson and Demetriou suggest that codified knowledge is learned through formal learning, and practical knowledge is learned through informal learning. Similarly, Samuel (2009) describes these two types of knowledge as public propositional knowledge, which constitutes theories about learning, sociology of education, policy etc., and as craft knowledge which is implicit, undeclared and gleaned from "the habits of rituals and routines that characterise school spaces" (p.745). Kelly (2006) uses a different set of terms to describe these same concepts.

Knowledge in practice & knowledge of practice

Kelly (2006) calls propositional knowledge 'knowledge-of-practice' and he calls practical knowledge 'knowledge-in-practice'. The latter is tacit knowledge grounded in professional activity, which cannot be easily articulated. Such knowledge can only be created by practitioners in the context of their practice. Marrow (2007) argues that practical knowledge must be informed by understanding. He argues that theory and practice are internally related to each other, and that in practice teachers must draw from both academic and technical knowledge. Resonating with Marrow (2007), Kelly suggests that teachers in the classroom draw on both knowledge-in-practice and knowledge-of-practice. These two kinds of knowledge cannot be understood or learned independently of each other. Developing professional knowledge draws together both propositional and practical knowledge (Eraut, 2000; Marrow, 2007). Professional practice does make use of technical knowledge, but it always involves more – it also requires judgement-in-practice.

Ontological commitments – personal knowledge

There is ample research that shows that what teachers do in their classrooms, their practice as such, is not only a result of their propositional and practical knowledge, but also of their 'ontological commitments' or personal knowledge (Desforges, 1995; Gudmunsdottir, 1991; Morine-Dershimer & Kent, 1999; Pithouse, Mitchell & Weber, 2009). These are deep-seated beliefs about the nature of disciplinary knowledge, the purpose of schooling, the role of the teacher, and the role of the learners, many of which are developed as a result of the teacher's own school experiences and their family and cultural norms (O'Sullivan, 2004; Samuel, 2009). Sometimes these personal beliefs conflict with research findings about good teaching practices; for example, that learners need to engage meaningfully with new material in order understand, rather than simply memorise it. In such circumstances, ideally for good teaching practice, this personal existing knowledge should shift. The shift would often take a long time.

Thus it becomes evident that the practice of teaching for organizing systematic learning is a complex issue that involves the development of propositional knowledge, practical knowledge and personal knowledge and that this learning also often involves relinquishing existing knowledge.

In Figure 1 below, I indicate how content knowledge, pedagogical knowledge, PCK and context knowledge, within the three broad categories of practical, propositional and personal knowledge shape teachers' practice. The figure illustrates how the different types of knowledge are necessary for the professional practice of organising systematic learning. I am of the opinion that PCK has a place in both the practical knowledge domain (for example, the use of specific pedagogic strategies to teach concepts in a particular subject, and of assessment strategies that are particular to a specific subject) and the propositional knowledge domain (for example, an understanding of how learners of different ages learn a particular subject; the particular explanations and analogies which are useful to use; the common errors of understanding that students make in a particular subject). My understanding is that practice is also shaped by contextual factors like professional activities and school ecology.

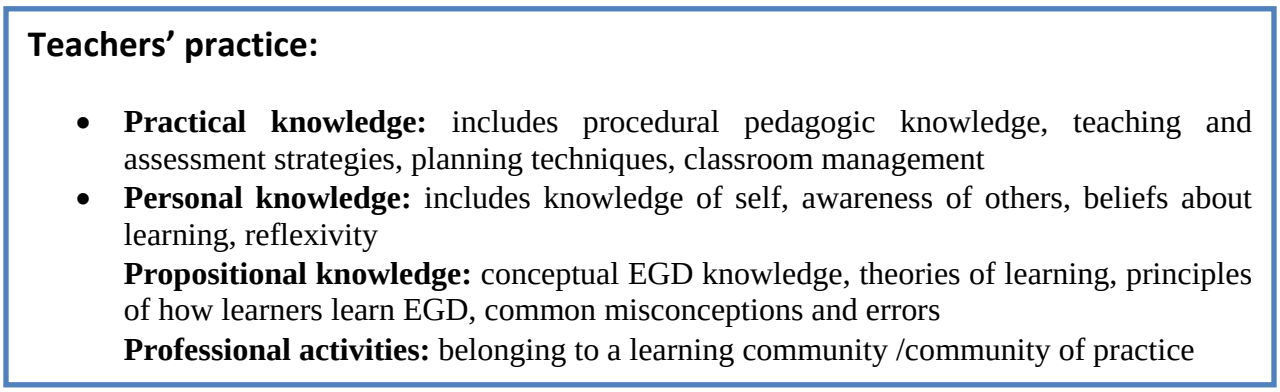


Figure 1: Factors that shape teachers' practice of AD

While discussing and describing teachers' professional knowledge and the contextual factors that shape their practice, there is also the implicit question of how teachers understand this knowledge. According to Zeidler (2002) teachers' understanding is shaped by their learning style, subject matter knowledge (SMK), the training received to teach, as well as the professional activities that teachers engage in. Subject matter knowledge refers to the teacher's understanding of the subject content that she/he teaches (Gudmundsdottir, 1987, p. 6). The depth and organization of this subject matter knowledge influences how structure and teach lessons (Wilson & Winberg, 1988). In other words, subject matter knowledge affects what and how they decide to teach. Research by Wilson and Winberg, (1988) confirms that teachers with shallow subject matter knowledge do not plan and structure their lessons and assessment for deep conceptual understanding of learners. A teacher's learning style impacts how accessible subject matter knowledge is to him/her as well as how he/she engages with the subject material. The types of initial teacher training received and the subsequent professional development received will either enhance or have no effect of teachers' SMK. The professional activities teachers are involved in affect their learning and consequently their SMK. Figure 2 below represents the factors that sculpt teachers' understanding.

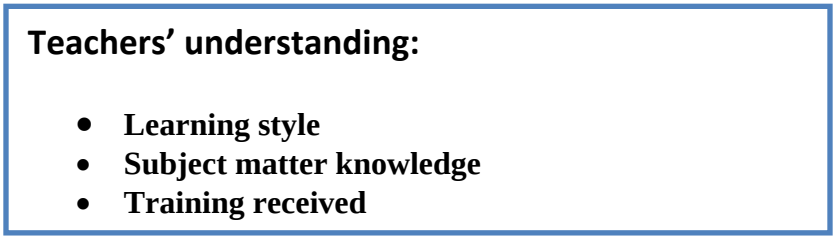


Figure 2: Factors that shape teachers' understanding of AD

2.5. Competencies required by EGD Teachers to teach AD

According to Abdulwahab and Usman (2014), teachers of EGD are expected to have certain competencies that will promote learning amongst learners. Their survey brings to the fore the competencies expected of EGD teachers in order to engage meaningfully with specific sections of the curriculum. For teaching AD, the teacher should be competent enough to, at least:

- Know how to dismantle, prepare parts list and make pictorial /orthographic sketches of the parts of a simple mechanical device
- Draw orthographic views – full and sectional – of simple assemblies, solving problems in link mechanism, true lengths, angles and surfaces
- Understand the principal and application of loci
- Draw and give examples of ellipse, parabola and hyperbola
- Use wood or paper to construct a simple link machine
- Recognize true and foreshortened lines and surfaces in projected views
- Determine the angle of an inclined line to the principal planes
- Demonstrate and sketch the concept of auxiliary planes
- Use auxiliary and cutting plane methods to determine the line of intersection of two meeting surfaces e.g. intersection ducts, prisms and cones
- Use wood and paper to model different objects from the understanding of development
- Explain graphically cam and gear motion
- Explain harmonic motion graphically
- Identify types of gears
- Draw meshing gear profiles from given data
- Draw and interpret simple electric and electronic circuits

The aforementioned competencies will be useful during observation of Grade 11 EGD teachers' practice of AD.

2.6. Conceptual framework

The key concepts in this study are teachers' understanding of AD and teachers' practice of AD, which thus form part of the conceptual framework. These two concepts have been reviewed extensively in section 2.2. In order to bring to the fore the interplay between teachers' understanding of AD and their practice of AD, I draw on Singh–Pillay's (2010) notion of interface. According to Singh-Pillay (2010), interfaces arise out of the points of convergence and divergence between the elements or people's views. It is this understanding that is applied in this study. The concept of an interface is construed for this study as a meeting point (convergence) or a point of deviation (divergence) between teachers' understanding of AD and their practice in terms of AD. During data analysis, the notion of interface will be used to look for convergences (congruence) or divergence (non-congruence) with regard to understanding of AD and practice of AD. This is illustrated below in Figure 3.

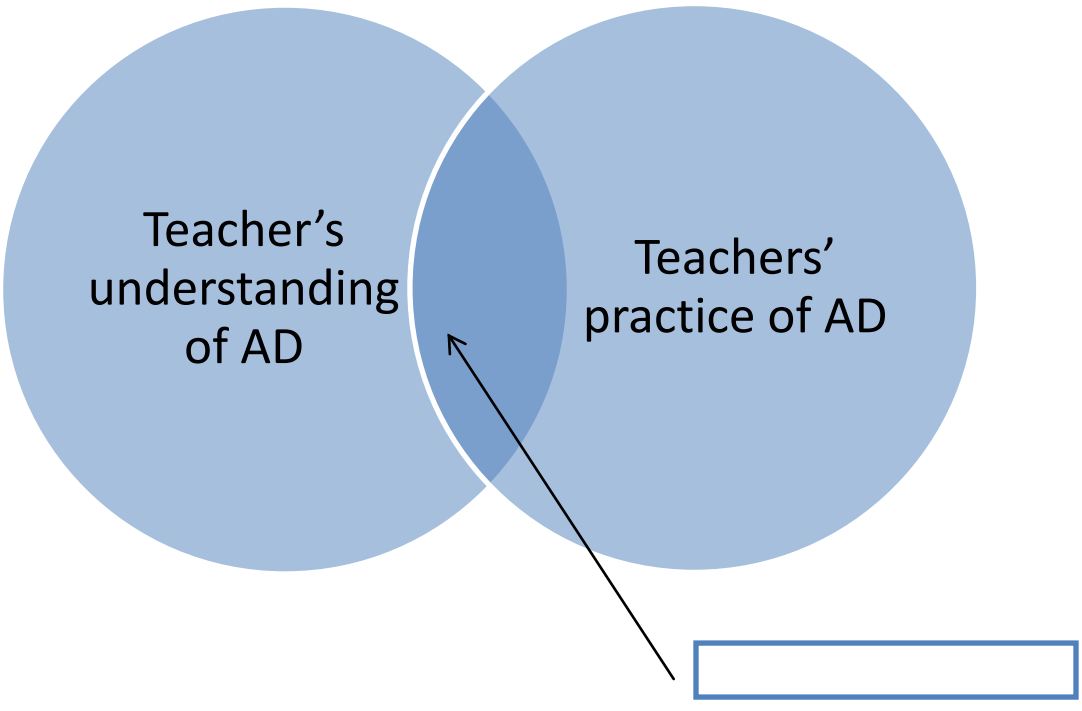


Figure 3: Interface between teachers' understanding of AD and their practice of AD

2.7. Conclusion:

In this chapter I surveyed literature that focuses on the shift from technical drawing to EGD to bring to the fore the change in context, assessment and methodology. Second, the Curriculum Assessment Policy Statement (CAPS) for EGD was surveyed to illuminate the content of the EGD school curriculum, and clarify what assembly drawing entails. Third literature pertaining to scholar's views on teaching practice that promotes learning in EGD/TD was examined in order to identify the strategies that could be deployed to address to the areas of weaknesses discussed in the national NSC EGD examiners and moderators report. I also examined literature that responded to question of what teachers need to engage in their practice and how it impacts their understanding. The conceptual framework that underpins this study is elucidated. Lastly a conclusion for the chapter is provided. The next chapter discusses the methodology deployed in this study.

Chapter Three

Methodology

3.1. Introduction

In this chapter I discuss the philosophical assumption underpinning this research, present the research method used in this study and explain why this study adopts a qualitative case study approach. It also describes the research site and the data collection methods. The chapter also describes how various gatekeepers at each stage of the research were approached in order to gain site access, and the hurdles encountered by the researcher during the data collection phase. The data collection instruments and sampling procedure used in the study are outlined. This is followed by the description of data collection procedures and the method of data analysis. The chapter ends with justifying the validity of the instruments and analysis procedures, in order to promote the credibly of the research outcomes.

3.2. Philosophical assumption underpinning this study

According to Weaver and Olson (2006, p. 460), “paradigms are patterns of beliefs and practices that guide the way we do things, or more formally establishes a set of practices”. In effect this means that the paradigm directs the thought patterns and actions undertaken in a study. Therefore it is essential to clarify the paradigm adopted in this study because it directs the structure of and methodological choices in the inquiry

This study is located within an interpretivist paradigm, which according to Cohen, Manion, and Morrison (2011) aims to understand, describe and interpret in detail the lived experiences of participants in a study. Accordingly, the interpretivist researcher seeks to understand and describe how people make sense of their worlds and make meaning of their actions or inactions. Resonating with the preceding ideas, Denzin and Lincoln (2011) contend that from an interpretivist perspective, human actions have meanings that can be determined by a researcher. Within this research framework the teacher is seen as a social being situated within a particular social background. Therefore, an interpretivist paradigm focuses on people’s subjective experiences, on how people construct their social world by shared meanings, and how they

interact with or relate to each other. As Maree (2013) explains, an interpretivist paradigm assumes that reality is not objectively determined, but instead it is socially constructed. In that sense, placing people in their social contexts offers a greater chance of uncovering their own perceptions of their activities. This implies that the uniqueness of a particular context is important for understanding and interpreting meanings constructed within it (Hussey & Hussey, 1997 cited in Maree, 2013). The foregoing ideas imply a need to examine or explore situations through the lens of the participants rather than through that of the researcher. The social background within which the teacher works is also influenced by contextual factors. Therefore such factors as resources and types of training received are considered when we examine teachers' understanding and practices of AD. Hence, the study draws from the assumptions of an interpretivist paradigm to explore the interface between Grade11 EGD teachers' understanding of AD and its practice.

3.3. Research Approach

The term 'research approach' refer to the method or strategy followed in studying a phenomenon in order to obtain further insight. There are essentially three research methodologies: the qualitative, quantitative and mixed method research approaches (Creswell, 2013). The choice of methodology depends on the paradigmatic stance and the purpose of the study. This study is designed to explore the interface between Grade 11 EGD teachers' understanding of AD and their practice of AD; therefore a qualitative research method is employed. The qualitative research method involves collecting descriptive data (verbal or textual) and recording observable behaviour (Cohen et al., 2007). In a qualitative research approach, the researcher is not merely gathering data (information), but he or she is approaching the empirical world in a specific manner. This means that the reason for the choices of qualitative method, and the researcher's choices and actions will determine the research strategy (De Vos, 2002).

According to McMillan and Schumacher (2010 ,p10) the goals of qualitative research are to "describe and explore" and to "describe and explain any phenomenon". In this study qualitative data was collected in order to gain a greater and deeper insight (Bertram, 2003; Kumar, 2005) into the interface between Grade 11 EGD teachers' understanding of AD and their practice of

AD. In order to access such views there needed to be room for flexibility at every stage of the research. Consequently, qualitative data was therefore deemed suitable because it allows for and captures a wide range of responses from observed situations and opinions of respondents.

3.4. Research Design

Research is distinguished form other observation by being designed and planned (Durrheim, 2002). In other words the research design is the plan of how the researcher will systematically collect and analyse the data that is required to give valid solutions to research problems.

The ontological position of an interpretative paradigm directs this study to employ a case study approach. According to Creswell (2013), a case study research approach is an empirical inquiry approach that investigates a phenomenon within its real life context. Lapan (2012) explains that the chosen case may be some aspect of the social life of a person or group of persons, an organisation or a phenomenon.

A case study is an in-depth exploration of a bounded system. (Creswell, 2013) highlights that in using the case study approach a researcher explores a real life, contemporary, bounded system or multiple bounded systems over a period of time, This system could be a person, group of persons, activities, events or processes. Similarly, Lapan (2012) asserts that one of the unique features of the case study approach is the exploration of something with clear limits or boundaries. Lapan (ibid) further explains that the case study researcher clearly and carefully specifies what elements of the case will be studied; that is, which portion of the program or the phenomenon is to be the focus of the investigation. Accordingly, I demarcate the case in question as the interface between Grade 11 EGD teachers' understanding of AD and their practice in the Uthukela district.

The case study approach is suitable when research is intended to explore and understand the details of some phenomenon. The method usually generates data for analysis as words, rather than numbers; that is qualitative rather than quantitative (Lapan, 2012). The intention in this study was not to judge teachers' understanding or practice of AD but rather to understand the

reasons behind these. The study involved real people in real situations and provides an in-depth study of participants' unique and common features in a limited time frame (Cohen, Manion, & Morrison, 2007; Denscombe, 2003; Kumar, 2005). In this way it fulfills Murray and Beglar's (2009, p. 21) description: "Case studies can be defined as the intensive, in-depth study of a specific individual or specific context or situation. The real strength of the case study method is its potential to illuminate a 'case' in great depth and detail and to place that case in a 'real' context The data may come from sources such as observation, interviews, documents or reports (Cresswell, 2013). In collecting qualitative data, the case study method allows participants the freedom to share their ideas, views, understanding, practice and experiences in their natural setting. Thus, participants can provide the desired depth of information in data (Cohen et al, 2013). In other words, a case study method is most suitable and useful when a researcher is seeking in-depth understanding of a specific event, process, organisation or group(s) of people in a particular setting.

The hallmark of case study approach, according to Lapan (2012) and Cohen et al, (2013), is that case study methodology provides thick descriptions of participants lived experiences of, thoughts about, and feelings for, a situation using multiple data sources. It is descriptive and detailed with a narrow focus, and combines subjective and objective data.

Lapan, (2012) and Cohen et al, (2013) suggests that the strengths of the case study approach lies in the fact that it is concerned with rich and explicit descriptions of events relevant to the case; it focuses on individual actors or group of actors and seeks for deep understanding of their perceptions of events.

The case study approach does justice to the context of a phenomenon. In this regard, Cohen et al ,(2013) argue that a qualitative case study provides a unique example of real people in real situations, so as to explain causes and effects in their real context. Choice of the case study method presupposes the important role of context in determining both causes and effects, so necessitating in-depth understanding in order to do justice to a situation. Cohen et al. (ibid) go on to explain that contexts are distinct and dynamic. Thus case studies investigate and report real life, complex, dynamic and evolving interactions in a unique instance, be they events, human

relationship or other issues. Similarly, Simons (2001), as cited in Thomas (2011), contends that a case study involves an in-depth exploration from a variety of perspectives to capture the complexity and distinctiveness of a particular situation, project, institution, program or system, in its real life context. In addition, Hitchcock and Hughes (1995) and Cohen et al, (2013) hint that the case study approach is particularly suitable when the researcher has minimal control over events; that is to say when behaviours cannot be controlled or manipulated. From the foregoing perspectives, context can be seen as a major factor in the case study research methodology, because it gives the researcher an opportunity to interact with participants in their natural setting or context, thereby allowing for in-depth understanding and interpretation of the phenomenon or case under investigation. Accordingly, the research design will provide for the unique contexts of the teacher participants.

In the case study method, the researcher is integrally involved in the case, because the case itself may be linked to the personality of the researcher. Thus, despite all efforts, the researcher may influence the collection and interpretation of data. Consequently the research design will need to incorporate checks in order to minimise this influence.

Drawing from the foregoing insights, of Cohen et al, (2013) and Maree (2013), I conclude that the case study approach seeks to answer the crucial ‘what’, ‘how’ or ‘why’ of the phenomenon under investigation and also provides a detailed explanation of the phenomenon being explored by focusing on specific instances in a bounded system. It can thus be argued from the above perspectives that a case study research approach allows for in-depth, thick, rich qualitative data as words, vivid descriptions, and insightful personal comments that will facilitate understanding the interface between Grade 11 EGD teachers’ understanding of AD and their practice of AD. The choice of a case study research methodology arises from the researcher’s desire to probe in order to gain an in-depth understanding of the phenomenon. The method emphasises the use of various data sources. Therefore, this research study adopted the case study method, because it allowed data to be generated from multiple sources. In particular, the method provides the researcher an opportunity to interview Grade 11 EGD teachers and observe their practice of AD in the real context where the phenomenon exists, which helps gain deeper understanding of the phenomenon under investigation. In exploring the teachers’ understanding and practice of AD, it is also necessary to understand aspects of their social context. Exploring this could include

finding out how they experience daily teaching in their immediate environment; or how, as teachers, they experience transitions and flux in their locality. Such enquiries can only be achieved using methods such as a qualitative case study which will generate data for analysis as words and expressions rather than numbers.

The distinguishing feature of case study approach is that it provides rich thick descriptions of the participants genuine lived experiences, their thoughts and feeling about a particular phenomenon, within a specific context, using multiple data sources.

According to Creswell (2013) and Cohen, et al, (2013, p. 291) a researcher can choose from different categories or types of case study approach. There are two systems to classify case studies. I will examine the first system used to classify case studies followed by the second system. These categories are distinguished by the nature and size of the bounded case, that is whether the case involves one individual, many individuals, groups of individuals, a process, an institution or an activity. Also, these categories of case study are distinguished by the intention and purpose of the study (Stake, 2000; Creswell, 2013). In this regard, Stake (2000), Lapan (2012), Creswell (2013) as well as Cohen, et al, (2013, p. 291) identified the following three categories of case studies; viz, intrinsic case study, instrumental case study and collective case study. The intrinsic case study aims to understand the particular case at hand (Cohen, et al, 2013, p. 291). According to Lapan (2012), an intrinsic case study focuses on the case being studied in order to develop a detailed understanding of the case at hand. The instrumental case study examines a particular case or instance to build new theories or to compare findings to earlier ones for corroboration or to question their validity (Lapan, 2012). The collective case study involves studying a number of cases (multiple case studies) jointly in order to investigate a phenomenon (Creswell, 2013). This method is believed to offer better understanding of the phenomenon or case.

The second system for the classification of case study research approaches, is based on the work of Yin (1994 cited in Cohen, et al , 2013, p. 291) and Robson (1993). These scholars identified three categories of case studies with regards to their outcomes. These include exploratory case study, descriptive case study and explanatory case study. An explanatory case study involves hypothesis testing. The descriptive case study focuses on providing narrative accounts. The

purpose of an exploratory case study is to provide new, detailed information on, or insight into, a problem or a process (phenomenon) through the research findings, which could perhaps inform policy or serve as the background for further research. This study embraces the exploratory case research study methodology. This choice is based on the purpose of the study being to explore the interface between Grade 11 EGD teachers' understanding of AD and their practice of AD. This approach aligns perfectly with the methods of generating data.

Adopting a case study design in the study has advantages. A case study does not prescribe any particular method for data collection, and so it allows the use of various methods in order to answer the research question (Bell, 1993; Denscombe, 2003). It provides a broadened view about varying human behaviours and exposes the views and choices of participants within a chosen context and that it addresses the 'how' and 'why' questions in research (Anderson & Arsenault, 1998).

Therefore a case study approach can offer is an in-depth understanding of how various aspects in the case interrelate. Case study is thus uniquely placed to deliver explanatory theory. The potential transferability of these findings to other similar contexts can only be partly suggested by the author; ultimately judging transferability is the responsibility of the reader, who can compare the case here to another context. In this sense then, it has been argued that the case study is associated with its own particular forms of generalizability (Flyvbjerg, 2006).

3.5. Location of the study

The study is located within the uThukela District in the province of KwaZulu-Natal, South Africa, as shown in the figure below.

SOUTH AFRICA

UTHUKELA DISTRICT

Figure 4: Map of UThukela district

The uThukela District has a population of approximately 714 918 people and there are 35 schools in this district. The Department of Basic Education has ranked all schools according to quintiles 1 to 4, with 4 being the most well-resourced schools. Quintile 4 consists of ex-Model C schools which have all required resources and are based in town or cities. There is one such school in this district. Quintile 3 schools have most of the necessary resources and are based in townships or locations. There are two Quintile 3 schools in this district. Quintile 2 schools are based in semi-rural areas. These schools remain disadvantaged in that they have minimal resources but are reasonably close to towns. There are five Quintile 2 schools in this area. The lowest ranked schools, Quintile 1, are situated in deep rural areas. These schools are poorly resourced learners travel long distances to and from school, often having to walk more than 3 km each way. Access to school presents an extreme challenge in bad weather conditions, when rivers may flood across bridges. The standard of living in the area is low, as the majority of the people are not working. If they work, they are usually employed in seasonal, temporary jobs for commercial farmers (uThukela, municipality, 2011). There are thirteen schools that offer EGD in this district, all of which form part of the sample. Table 4 reflects the quintile ranking of the schools in my sample.

Table 4: Quintile ranking of schools in this study

Quintile ranking	Description	Number of schools
1	Deep rural	4
2	Semi-rural	5
3	township	2
4	Ex- model C	1

The table above shows that the majority of schools in the uThukela district are poorly resourced, with only three schools being near a large town or having most of the necessary resources.

3.6. Data collection methods

Data collection methods are tools used by a researcher to collect data as required in order to answer the relevant research questions. The tools most often used in education research include questionnaires, tests, interviews, observations and focus group discussions (Lauer, 2006).

Data can exist in two ways. It could be pre-existing information, waiting to be accessed, such as school records or census data. This is known as secondary data (Kumar, 2005) because of their having been already analysed at least once since collection. Data collected directly and first-hand from the source, such as interviewing and/or observing people or collecting questionnaire responses, are referred to as primary data (Bertram, 2003; Cohen et al., 2007; Denscombe, 2003). For this study the data are entirely from primary sources. In this section I discuss issues pertaining to gaining access, instruments used, sampling methods, phases of data collection, how data was analysed as well as how issues of trustworthiness, validity and reliability were addressed.

3.6.1. Gaining access

According to Durrheim & Wassenaar (2002), the code of ethics for research is concerned with the researcher's attempt to value human rights. There are number of ethical considerations that must be observed when doing research among humans, because it may be invasive and complex (de Vos et al., 2005). One ethical aspect is gaining access to a site and/or participants, which means dealing with various gatekeepers at each research stage, as is explained next.

Prior to conducing this study, formal permission to conduct research was first obtained from UKZN's research office, which included the ethics committee, and the KZN DoE. Permission to conduct research was then obtained from the relevant school principals in the UThukela District. Once I had gained the principals' consent to conduct research at their schools, I finally sought permission from individual Grade 11EGD teachers to include them in this study. Whilst requesting the teachers' permission, I informed them verbally about the background and purpose for the study. Participants were also made aware that they could choose to withdraw from the study at any time, and they would also be guaranteed confidentiality and anonymity. I also

informed teachers about how I intended to collect data; which at that stage included a task-based activity, questionnaires, observations, and post-observation interviews. Teachers vehemently objected to the use of a task-based activity to gauge their understanding of AD. They argued that such an activity could portray them in a negative light if they fared poorly in it and this would be humiliating and so affect their professional identity and self-esteem. They shared with me previous negative encounters and experiences of EGD teachers who had been ridiculed at the matriculation examination marking center for having obtained low marks whilst answering the examination paper. I was even approached by a member of a teacher union who asked me not to ridicule or humiliate would-be participants in my study by subjecting them to a task-based activity. Responding to this objection, I had to abandon the idea of using a task-based activity as an entry point in the study, and consequently made adjustments to my data collection plan. The adjustments included a focus group interview with Grade 11EGD teachers (see section 3.6.2.2.).

I have come to realize that gaining access is an incremental process of dealing with various gatekeepers at each stage of the research. For example even though the principals of eleven schools had granted me access to their schools and each of the eleven EGD teachers had consented to participate in the study, participants from two schools had to be repeatedly reminded to return the completed questionnaire. They did eventually return their completed questionnaire well after the agreed date, citing examination pressure as a reason. A methodological challenge encountered during the observation of lessons was teachers' having to adhere to the standardized work schedule (a weekly and daily forecast of teaching and learning activities as outlined in the CAPS document). As a result, dates for observation of lessons had to be scheduled to coincide with the lessons when the AD processes were being taught.

3. 6.2. Data collection instruments

Several instruments were used to capture data to answer the two research questions posed: namely, a questionnaire, focus group interviews, observation of lesson and pre- and post-observation interviews. The instruments mentioned were used because they were suitable instruments for collecting qualitative data, as determined by the research design.

3.6.2.1. Questionnaire

An open ended questionnaire (see appendix B1) was designed with the assistance of university education researchers. An open ended questionnaire was deemed suitable to collect data for this study because it could capture the specificity of the particular situation (Cohen et al., 2007). In this regard, because I was seeking insight into the interface between Grade 11 EGD teachers' understanding and practice of AD, I anticipated many possible answers. In the light of this, Cohen et al. (2007: p. 321), in citing the work of Bailey said that "Open ended questions are useful if the possible answers are unknown or the questionnaire is exploratory". Cohen et al. (*ibid*.) add that open ended questions facilitate respondents giving answers without any restrictions, and this makes it suitable for enquiry into complex issues, which by their very nature demand more than simple, prescribed choices. The rationale for starting data collection with the questionnaire was twofold. First, it allowed participants the opportunity to answer the questions privately, with information written down their own words. This reduced the possibility of the researcher misinterpreting information and then misrepresenting it in the field notes. Second, analysis of the responses to the questionnaire helped in selecting the sample for the second phase of data collection.

A pilot study serves to increase the reliability, validity and practicability of the questionnaire (Cohen et al., 2011). Accordingly, the questionnaire was first piloted with EGD teachers from another district to check the clarity of the questionnaire items, and eliminate ambiguities or difficult wording. The outcome of the piloting indicated that the questionnaire items had good construct validity .Minor changes were made to the wording of two questions to improve readability. The final questionnaire targeted teachers' biographical data and then information on understanding of AD, planning for teaching AD, strategies used to teach and assess AD, and aspects of the AD that are emphasised during teaching. The information obtained from the questionnaire was used to map the Grade 11 EGD topography within the uThukela district in terms of teacher understanding and practice of AD.

Copies of the questionnaire were delivered personally to fifteen Grade 11 EGD teachers at their respective schools in the uThukela district. Teachers were given a one week in which to

complete the questionnaires in their own time, after which it would be collected from them. As a follow-up measure, telephone calls were made to respondents after four days to remind them to complete the questionnaire timeously, as suggested by Kerruish, Settle, Campbell-Stokes, & Taylor (2005). Contrary to my expectation, it took two weeks to retrieve the distributed questionnaire. One teacher, who had already agreed to participate in this study, returned a questionnaire that only included biographical data. It was evident from discussion with him and from the paucity of answers to my verbal questions that he could not answer the other questionnaire items concerning EGD. Another teacher failed to complete and return the questionnaire but in that case, perhaps due to lack of time, as he had repeatedly asked for extensions. The completed questionnaire were then coded from T1 to T13 (Teacher 1 to Teacher 13), so representing the thirteen respondents and then analysed.

3.6.2.2 Focus group interview

A focus group interview was introduced as a data collection method when teachers objected to the task based activity as an entry point into the study. I opted to use a focus group interview as it allowed the researcher to further probe and gain insight into the participants' questionnaire responses about their understanding of AD and their practice of AD. Furthermore a focus group interview will generate debates amongst the participants when they present their understanding and practice of AD and this in turn will provide the researcher will a deeper insight on participants understanding and practice of AD. All participants, who completed the questionnaire, were invited to participate in a focus group interview. The focus group interview was video recorded to capture both verbal and non-verbal information. Longhurst (2010) quote the explanation given by Krueger and Casey (2009) that interviewing is about talking, but it is also "about listening. It is about paying attention. It is about being open to hear what people have to say. It is about being non-judgmental. It is about creating a comfortable environment for people to share". In other words, the researcher has to be careful and systematic with the information in peoples' responses. Consequently, a semi-structured interview format was decided upon, which is also referred to as an informal, conversational or soft interview. The purpose of the focus group interview was to sample the respondents' responses by asking each of them questions in the same order thereby increasing comparability of responses (Cohen et al.,

2007). The focus group interview was used to probe and provide further information about the following topics: teachers' understanding of AD, methods used to teach AD, reasons for using the methods mentioned, kinds of activities given to learners during AD (see appendix 3 for the interview questions). Responses were analyzed as described in Section 3.8, phase 2. The focus group interview was then also used to identify the sample for the next phase of data collection.

3.6.2.3 Observation schedule

Observations entail being present in a situation and recording impressions of what takes place, then interpreting the meaning of the observed behaviour (Somekh, 2011). Observations take place in real-world settings, where programmes are subject to change and redirection. With fieldwork observations, researchers are in direct contact with the setting and the people they are observing. This direct observation gives researchers first-hand experience and thus enables them to generate detailed descriptions of the setting, the activities, interactions and participants' experiences. Observation also allows the researcher to compare what is written in official programmes to what actually takes place. First-hand experience on site is also important in providing insights that might be missed if the researcher relied only on other people's descriptions of the setting (Patton, 2002). Good inquiry through observation thus documents what is actually happening. Through direct observation, a researcher sets out to document, accept and understand the complexities of a changing situation, including what may be unanticipated but emerges as important in understanding the participants' experiences.

Observation provides "a form of '*primary data*" (Yin, 2011 p. 143) because researchers use their own senses to generate data, instead of relying on what has been previously reported by someone else. Similarly, Cohen, et al, (2007, p. 396), note that observation "offers a researcher the opportunity to gather 'live' data from naturally occurring social situations"; specifically by looking directly at what is happening, instead of relying on second-hand accounts. Cohen et al. (2007) point out that observation potentially produces more valid or authentic data than that obtained through reading a second-hand account. Likewise, the strength of observations is that it gives direct access to social interaction. Thus, observation data enriches and supplements data gathered by other techniques and so enables triangulation (Simpson & Tuson, 2003), see section 3.10.5.

In the light of the aforementioned ideas, an observation schedule was designed with the assistance of university researchers. Its role was to facilitate recording data gathered when observing teaching of AD at three schools (see appendix B2 for observation schedule).

The purpose of the lesson observations was to gain insight into the teachers' practice and to capture any possible disjuncture between teachers' understanding of AD and their practice. The semi-structured observation schedule enabled the researcher to gather data on the physical, human, interactional and programme settings. The physical setting involved the physical environment and its organization. The human setting involved the organization of people; and the characteristics and makeup of the groups or individuals being observed. The programme setting involves the curriculum and pedagogical style. The interactional setting involves formal and informal, planned and unplanned verbal and non-verbal interactions that take place during observation (Cohen, et al., 2011). It focuses on how the lesson was introduced, methods used in teaching assembly drawing, how learners' needs are catered for, as well as the kinds of activities in which they engaged.

Following the analysis of data form focus group interviews, three Grade 11 EGD teachers were purposively selected to have their lessons observed. The selection criteria were based on their understanding and stated teaching practice of AD.

3.6.2.4 Post-observation interview

Post-observation interviews were conducted with the three teachers whose lessons had been observed (see appendix B for post-observation interview protocol). The purpose of the interview was to probe further, and so gain more insight into, what had been observed during their lesson on AD.

Post-observation interviews provide more flexible opportunities to probe for greater depth than do a video recording or observation notes. Because the research focus was not only to explore

how teachers' understanding of AD interfaces with their teaching of AD, but also to gain insights into their thinking and reasoning in the process of knowledge transformation, and their reflection in and on action (Park & Chen, 2012; Schön, 1983, 1987). The post-observation interviews were thus used in the study to clarify, supplement and support what had been observed in the classroom and to provide further information that could not be captured by observation alone.

3.7 Sampling

Tashakkori and Teddlie (2010, p. 356) define sampling as "a process of selecting a subset or sample unit from a larger group or population of interest", as determined by the purpose of answering the research questions. Accordingly, Cohen et al. (2007), refer to sampling as a process of decision-making about the population (community), settings, events or deeds that have been chosen for observation. Convenience sampling as well as purposive sampling will be used for the study. *Convenience sampling* according to (Maree,2013) refers to "situations when population elements are selected based on the fact that they are easily and conveniently available" (p. 177). In this study, convenience sampling is chosen on the grounds of proximity and affordability, as I have access to schools in the uThukela District. *Purposive sampling*, according to Johnson and Christensen (2008, p. 239) happens when the researcher specifies the characteristics of a population of interest. It therefore allows a particular sample to be chosen because it illustrates some feature or process that is of interest in the study (De Vos, Strydom, Fouche, and Delport, 2005, p. 328). Tashakkori and Teddlie (2010, p 358) describe this type of sampling as a "critical case" sampling scheme, because the technique involves selecting a groups or individuals, based on specific characteristics, because their inclusion provides the researcher with compelling insight about the phenomenon of interest. Therefore, participants are selected because of the data they hold (Creswell, 2010). The participants in this study are also purposively selected as they are Grade 11 EGD teachers from schools with quintile rankings 1-4 and varied learner performance. For the latter I ensured there were teachers in each of three possible bands for EGD passes in the National Examinations for Grade 12; that is over 75%, below 75% but over 50 % and below 30%). The teachers were therefore chosen as they had a variety of experiences, so as to offer a potentially rich and valuable source of information that

would provide a deep insight into teachers' understanding of and practice in AD, thereby answering the research questions of the study.

3.8. Data Generation Plan

The table below shows the four phases in data collection, related to the data source, the instrument used, the research question in focus, and the purpose of the phase. The table thus shows an overview of my data generation plan.

Table 5 Data collection

Phase	Data source	Instrument	Research question/s targeted	Purpose of phase
1	11 Grade 11 EGD teachers	Questionnaire	1. What is EGD teachers' understanding of AD? 2. How do they teach AD?	To allow teachers the space to express their views on AD in an anonymous, open-ended way.
2	11 Grade 11 EGD teachers	Focus group discussion	1. What is EGD teachers' understanding of AD? 2. How do they teach AD?	Findings from phase one will be presented to participants, they will be asked to comment on the findings presented to clarify, add to and validate data obtained.
3	3 Grade 11 EGD teachers who participated in phase 2 of data capture –selected purposively – based on analysis of Phase 1 & 2 data Teaching portfolio – specifically tests/assign ments/ class exercises /homework	Pre-observation Interview Observation schedule. Post - observation interview. Document analysis – content analysis. -	1. What are EGD teachers' understandings of AD? 2. What is their practice of AD?	To gain a deeper insight between the teachers' espoused understanding of AD and their actual practice in respect of AD and to note convergences and divergences between espoused view and actual practice. .
4	Data from phase 1-3.	Juxtaposing data from phases 1-3.	3. Is there an interface between Grade 11 EDG teachers' understanding of AD and their practice of AD? If so, what is the nature of the interface?	Establish whether or not an interface exists and to describe the nature of the interface, if it exists.

Table 5 above indicates four data collection phases and shows how data from one phase leads into selection of participants for the next phase, as is explained next.

Phase 1

In the first phase, a questionnaire was used to collect data for two reasons. Its first purpose was to seek biographical data from the teachers and the second was to seek information about their understanding of AD, teaching and assessment used in Assembly Drawings, and their reasons for using these methods. As mentioned earlier in section 3.6.2.1. the questionnaire had been previously piloted to check the clarity of the questionnaire items, eliminate ambiguities or difficult wording and to increase the reliability, validity and practicability of the questionnaire. The questionnaires were hand-delivered to schools in the Uthukela District in order to give me an opportunity to personally explain the purpose of the study to participants and obtain their informed consent to participate in this study. Thirteen suitable responses were received.

Phase 2

During phase 2, focus group interviews were conducted with the 13 participants from phase 1 of data collection. In the interviews the interviewer was able to probe further into questionnaire responses and participants are given the opportunity to clarify and justify their responses. The focus group interview was video-recorded. Video recordings can capture non-verbal data (body gestures, facial expression, and tone), which audio recordings cannot or that an observer may miss. Another advantage of using video recordings is that they are an accurate image of what occurs, and allow for repeated viewing and checking. The repeated viewing and checking of the video recording thus serves as a means of data validation. The audio portion of the video recordings were transcribed and sent to participants for member checking, as explained in section.

Phase 3

During phase 3, an observation schedule (Appendix C2) was used to frame observations of how teachers teach AD. Three of the participants from phase 2 were purposively selected, based on the analysis of questionnaire responses. So as to be manageable for time and budget, I had decided to observe only three teachers. A pre-observation interview was conducted to obtain information about the 'what', 'how' and 'why' aspects of their practice pertaining to AD, according to the protocol in appendix B3. Observation of lessons was video-recorded. A post-observation interview was then conducted to follow up on the practice observed, see appendix B4. All pre- and post-observation interviews were video-recorded. Each of the three teacher's teaching portfolio, comprising tests, assignments, homework and class exercises, were also subjected to document analysis to establish their practices in respect of AD.

Phase 4

During phase 4, data from research questions 1 to 2 was (re)assembled and juxtaposed to first establish if an interface exists between Grade 11 EGD teachers' understanding of AD and their practice of AD, and then to describe the nature of the interface.

3.9. Data Analysis Methods

Following the four data collection phases, and running concurrently with later phases, there were three data analysis stages. According to Cohen et al. (2011), analysis of qualitative data involves organising, accounting for and explaining the data in terms of the participants' conception of the phenomenon being explored, noting patterns, themes and categories and regularities. Data from the three stages was analysed by a deductive approach. Deductive analysis involves a systematic procedure for analysing qualitative data where the analysis is guided by specific objectives (Cohen et al, 2011). Using this approach, all the relevant data from different sources (questionnaire, focus group interview, and observation schedule) are collated to provide a collective answer to a research question. In this study, Grade 11 EGD teachers' understanding and practice of AD are the unit of analysis. The conceptual framework developed (see chapter 2,

section 2.6) was used during the analysis. The three research questions posed in this study will inform the organization of data for analysis at each stage.

Stage 1: Content analysis of data

The analysis commenced after the questionnaires had been returned.

For research question 1 (What are Grade 11 EGD teachers' understanding of AD?) I engage in content analysis. Content analysis, according to Cohen et al. (2011), is a systematic set of procedures for rigorous analysis, explanation and verification of the content of written data. It is a technique for making replicable and valid inferences from text to the contexts of their use. In this case the data was in the questionnaire responses. The responses were read several times before coding of the open ended questions could begin. The four categories pertaining to the assembly drawing (personal knowledge, practical knowledge, propositional knowledge and teachers' understanding) identified in the literature (see section 2.3.for more details) influenced the identification of codes during analysis. The categories identified from the data did not correspond one-on-one with the four categories from the literature survey. Codes sharing the same characteristics were grouped into categories and finally four categories emerged from the data (see section 4.3.).

Stage 2: Thematic analysis

According to (Cohen et al., 2000) analysis of qualitative data involves organizing, accounting for and explaining the data in terms of each participant's or the participants' conceptions of the phenomenon being explored, while noting patterns, themes and categories and regularities. Data generated through the focus group interviews, observations, and pre- and post-observation interviews were analysed in five stages using the thematic method (Clarke & Braun, 2013; Hesse-Biber & Leavy, 2011). The first stage was transcription of all the recorded data. The second stage was reading and familiarisation with interest on items noted. This was followed by open source coding through close examination of the data using the questionnaire items from our interview. Fourthly all the relevant data from all data instruments, now also including questionnaire responses, were collated to provide a collective answer to the research question. Finally, themes were sought; a matrix was developed to initially help distill out the various

themes which had emerged (Creswell, 2009) and then to identify any connectedness between them; thereby assisting in collapsing or merging themes.

Stage 3: Juxtaposing data

This stage addressed research question three. Data used for the first and second research question was further analysed using the interface concept (Singh-Pillay, 2010). This was achieved through cross-analysis, whereby the themes that had emerged from the earlier analysis were juxtaposed. The juxtaposition highlighted points of convergences and divergences between Grade 11 EGD teachers' understanding of AD and their practice of AD. From these points the nature of the interface could be described.

3.10. Research vigour

Every research study is subject to an open critique and evaluation. Without this, the soundness of its methods, accuracy of findings, the quality of assumptions made and conclusions reached are questionable and could reduce the value of the study, (Long & Johnson, 2000, p. 30). Results of data collected and analysed in my study were exposed to criticisms from other researchers in the field of study, as will be explained later in Section 3.10.1. Nevertheless, I indicate below how this research has been designed to avoid or minimise challenges to its validity.

3.10.1. Validity

Validity is a term used in qualitative research, which indicates whether the researcher is actually carrying out the research as proposed. It is achieved through a consistent check on the research instrument for objectivity, and the data for consistency. Ensuring objectivity is not an abstract activity; rather, it should dictate all efforts undertaken to ensure that the research evidence does back up the research claims (Silverman, 2010, p. 366). Because qualitative data does not allow for statistical testing, in qualitative research significant attention is given to internal validity. In this regard, Yin (2008) recommends that different responses from participants in the group be checked for consensus. In other words triangulation is needed, as explained in section 3.10.5.

More so, to achieve internal validity, methods such as pattern matching, explanation building, logic models, or addressing conflicting descriptions are used. As stated by Amerson (2011, p. 428) “construct validity can be achieved using several sources of evidence, sustaining an arrangement of proof, and having a key informant review the draft of the case study report, or through member checking”. Consequently, construct validity necessitated having several sources of evidence; all video recorded interviews were kept safely and reviewed during analysis to avoid uncertainty. Furthermore, during the pre- and post-observation interviews, I asked participants for clarity where there were divergent views in order to ascertain a consensus response which helped to achieve internal or construct validity.

Furthermore, many researchers in qualitative research submit that to evaluate and ascertain the quality of a qualitative research work, terms such as trustworthiness, relevant, confirmable, credible, dependability, transferability or plausible are used (Denzin & Lincoln, 2005, p. 24). Accordingly, to enhance the worth of my research I have adopted the notion of credibility as well as internal or construct validity.

3.10.2 Credibility

In order to ensure credibility of my study, data was collected to ensure detailed description of the settings, participants and themes of my study, as recommended by Creswell & Miller (2000, p. 128). These aspects are discussed next.

3.10.3. Member checking

Member checking is a research procedure used to ensure credibility and validity of the research. According to (Carlson, 2010), member checking involves taking the interview transcript back to the participants and asking them to verify the accuracy of the parts that they had contributed. Through this process participants are given the opportunity to elaborate, clarify or confirm aspects of the interview in order to ensure that their views, experiences and perceptions had been captured accurately during the interview. Thus, member checking was adopted to enhance the credibility of the research. To be specific, each participant was checked their transcripts for accuracy.

3.10.4. Reflexivity

Reflexivity was also used to enhance the credibility of the data. I declare upfront how my background and roles as an EGD subject advisor and a lecturer on EGD at a tertiary institution holds the potential for shaping my interpretations. Furthermore, the results of the data collected and analyzed, and the findings of this research will be open to critique by other academics and researchers in this field of study. This is to ensure the soundness, accuracy of the findings and conclusions reached.

3.10.5 Triangulation

Triangulation is an important means of ensuring validity. It is done to increase credibility and check dependability and is accomplished by using information from multiple sources to form themes (Creswell & Miller, 2000, p. 126), which should then contribute to a coherent 'picture'. To prevent bias and improve trustworthiness in this study, data were collected through a questionnaire, focus group interviews, observation of lessons on AD as well as pre- and post-observation interviews. These data were triangulated during analysis.

3.11. Limitations of this study

As this is a case study and sampling was purposive, the results of this study should not be generalized. Nevertheless, as mentioned previously in section 1.5., a single case study can be regarded as valid, as was the case with Newton and Gailileo. The case study method allows for an in-depth and detailed study of Grade 11 EGD teachers' understanding of AD and their practice of AD, because it provides rich, thick descriptions of their situation (Shuttleworth, 2008).

3.12. Conclusion

This chapter shows that the study is located within an interpretivist paradigm, and uses a qualitative approach. This approach allows the explanatory case study method to be used with convenience and purposive sampling of Grade 11 EGD teachers from 11 schools in the uThukela district. Fine-grained data was collected through questionnaires, interviews, and on-site observation. The methods of content and thematic analysis were used to analyse the data. While

acknowledging the limitations of case studies, validity in the sense of credibility and trustworthiness are enhanced by member checking. In the next chapter I present the finding and analysis of the data collected.

Chapter Four

Presentation of findings and discussion

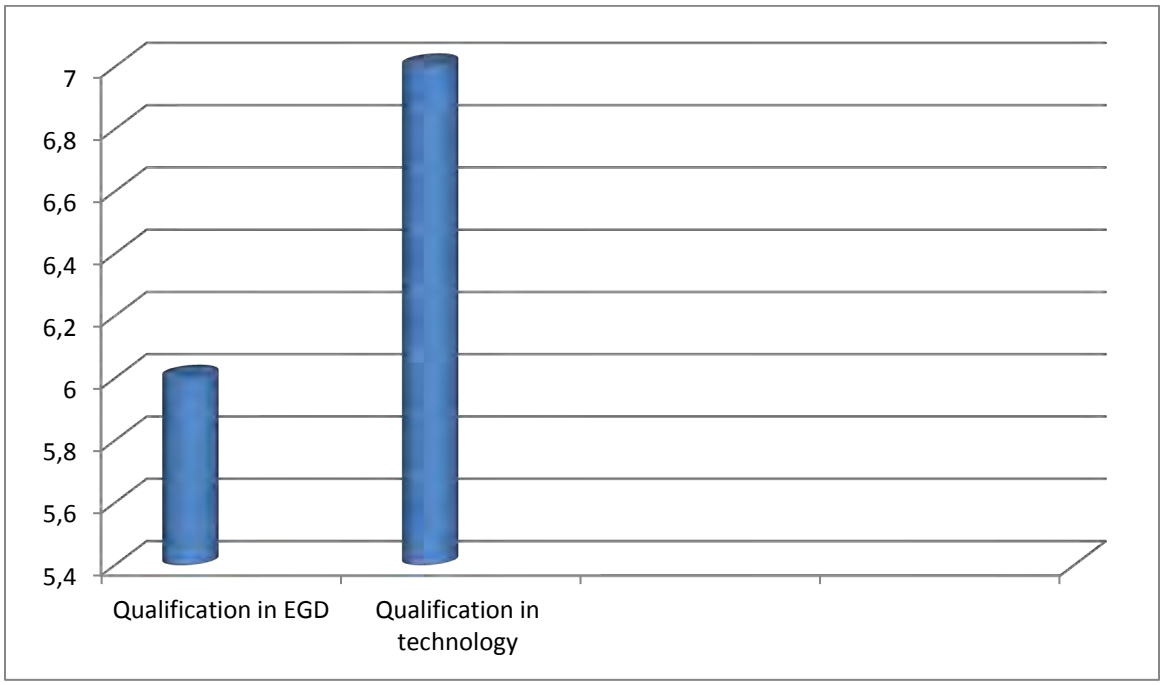
4.1. Introduction

This chapter aims to present data so as to answer the three research questions posed, specifically: (i) What are Grade 11 EGD teachers' understanding of AD? (ii) What are Grade 11 EGD teachers' practice of AD? (iii) Is there an interface between Grade 11 EGD teachers' understanding of AD and their practice of AD? If so, what is the nature of the interface? As mentioned in the previous chapter, data was collected using a questionnaire, focus group discussion, observation, and pre- and post-observation interviews. The chapter is divided into 4 parts, A, B, C and D. Part A pays attention to biographical data obtained via the questionnaire to create the topology of who engages with AD in the uThukela District, part B aims to answer the first research question, part C attempts to answer the second research question and finally part D proposes to answer research question three.

4.2. Part A: Topology of who engages with AD in uThukela District

The data acquired from the biographical section of the questionnaire was used to create a topology or context for Grade 11 EGD teachers teaching AD within uThukela district. This section of the questionnaire focused on the teacher's qualifications, schooling background, gender, teaching experience, teaching workload, professional activities pertaining to EGD, as well as whether they had attended any training to assist with implementation of the new EDG curriculum.

Graph1 below highlights the qualifications of the teachers teaching EGD in uThukela district.

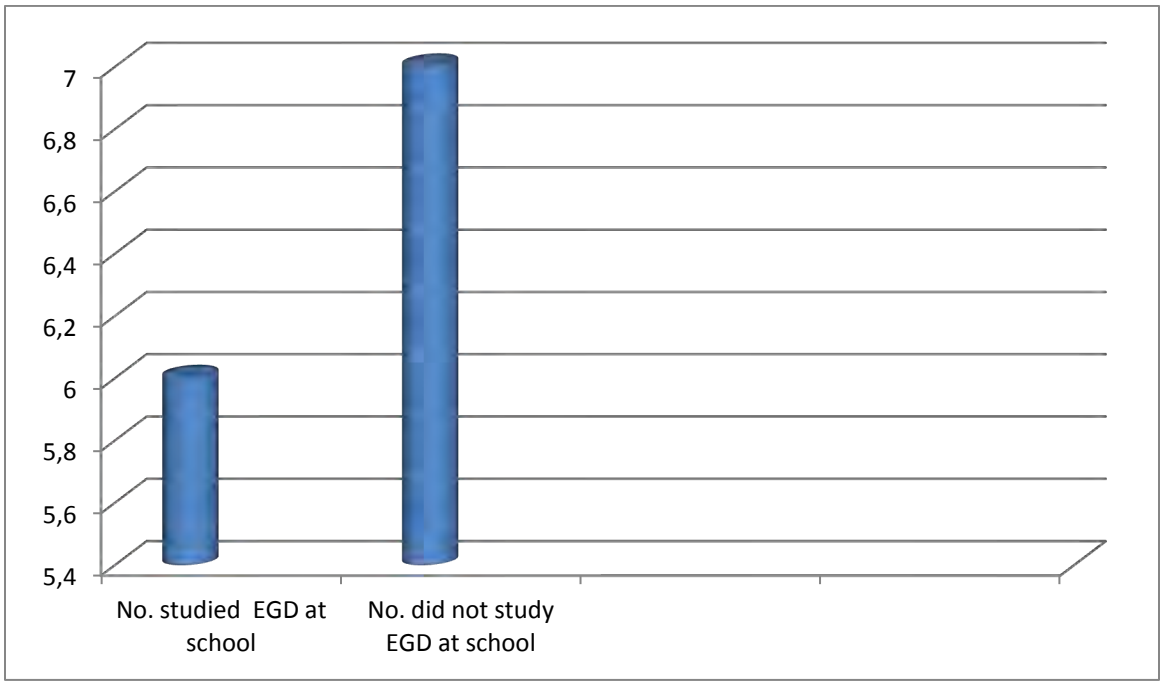


Graph 1: Teaching qualification of EGD teachers in uThukela district.

Six out of the thirteen teachers have a 4 year qualification to teacher EGD and seven teachers have a four year qualification to teach technology education. Whilst EGD and technology education are closely related learning areas, their underlying distinction lies with the design process (Fantz, Miranda & Siller, 2010). In technology education the design process concentrates more on the building and testing aspects, while the engineering design process is more focused on the analysis of the design (Hill, 2006). Furthermore the CK (content knowledge), SMK (subject matter knowledge) and PK (pedagogical knowledge) required to teach each of these subjects is very different (Branoff & Dobelis, 2012). This means that significant questions exist around the required content knowledge needed to teach AD. Can a professional not trained in EGD deliver lessons that are valid in content and context?

Based on their qualification, one could assume that the six teachers qualified to teach EDG have curricular knowledge to engage with effective teaching and learning AD (Bucat, 2004). In other words, the expectation is that these teachers ought to have the CK, SMK and PK needed to teach EGD. Looking at all the teachers' history prior to their tertiary studies, an examination of the

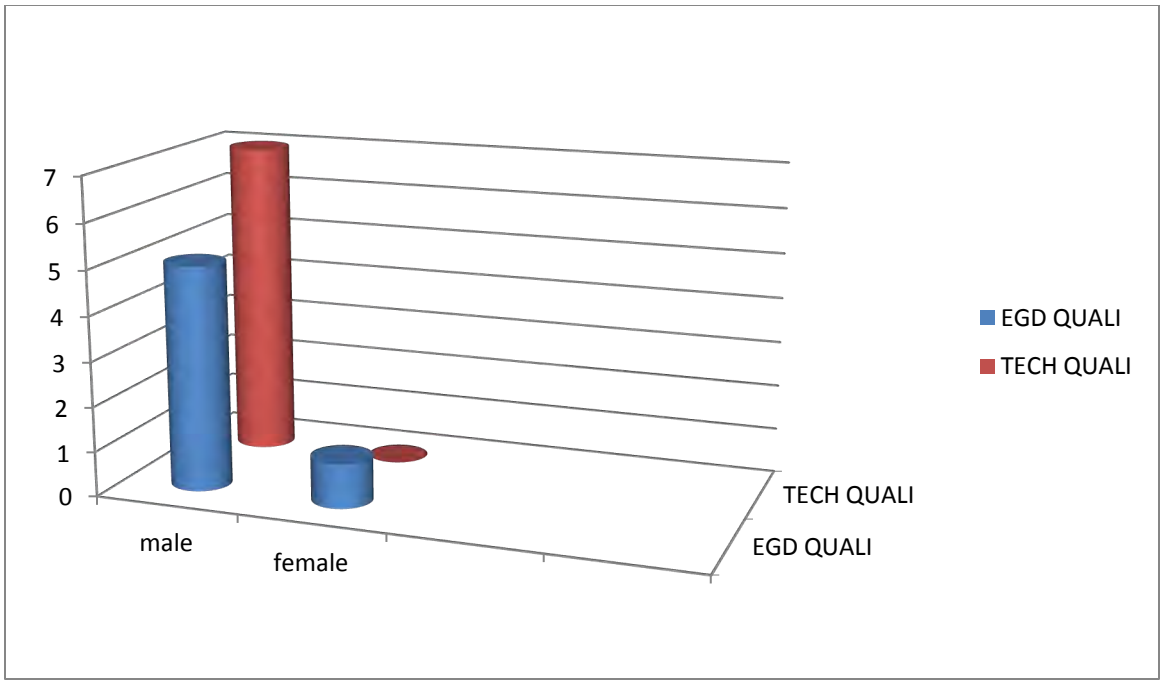
teachers' schooling background revealed which of them had studied EGD (previously known as Technical Drawing) whilst at school. This information is displayed in graph 2 below.



Graph 2: Teachers' schooling background

From the graph above it is evident that 6 of these teachers studied EGD at school and that 7 of them did not study EGD at school. Therefore 6 teachers have been exposed to the foundational background of EGD and according to Brink et al. (2003) and Khoza (2013) should have the basic knowledge and skills of EGD. Tracing these teachers' schooling background to their qualification unveils that the 6 teachers with a schooling background in EGD also pursued a qualification in EGD.

A closer analysis of these teachers' qualification to teach EGD exposed those who engages with EGD in this region. Graph 3 below shows gender distribution of those teachers teaching EGD.



Graph 3: Gender distribution of teachers teaching EDG

It is worth noting that of the 13 teachers teaching EGD in this region there is only one female. She is also one of the 6 teachers with an EGD teaching qualification. This gender bias raises questions on whether environmental factors such as social stereotyping, or perhaps visual skills in perception and mental rotation of objects has contributed to the asymmetric distribution in graph 3. In this regard, studies by Sorby (2009) and Sorby & Veurink (2010) highlight that men generally perform better than women in tests on spatial perception and mental rotation of objects. Furthermore, Vasta, Knott, and Gaze (1996) indicate that environmental factors such as educational experience, childhood play, parenting style can either increase or decrease the score gap between genders in terms of spatial perception and mental rotation of objects.

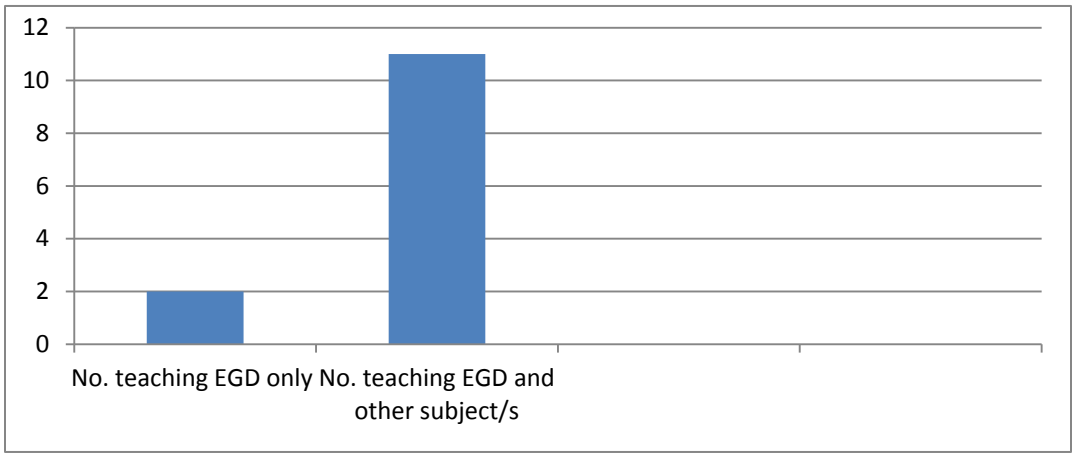
With regard to years of EGD teaching experience, there are noteworthy differences between teachers who have a qualification to teach EGD and those who have a qualification to teach technology education. The preceding differences are highlighted in Table 6 below.

Table 6: Years of teaching experience in EGD

Teachers with EGD Qualification		Teachers with TECH Qualification	
Teacher	No of years teaching	Teacher	No of years teaching
T1	15	T7	1
T2	17	T8	4
T3	10	T9	4
T4	13	T10	4
T5	11	T11	4
T6	14	T12	7
		T13	9

Table 6 makes evident the disparity in teaching experience between teachers with a qualification to teach EGD and those qualified to technology education. Teachers who are qualified to teach EGD have all been teaching EGD for a longer period (at least 10 years) compared to any of those with a technology education qualification (less than 10 years).

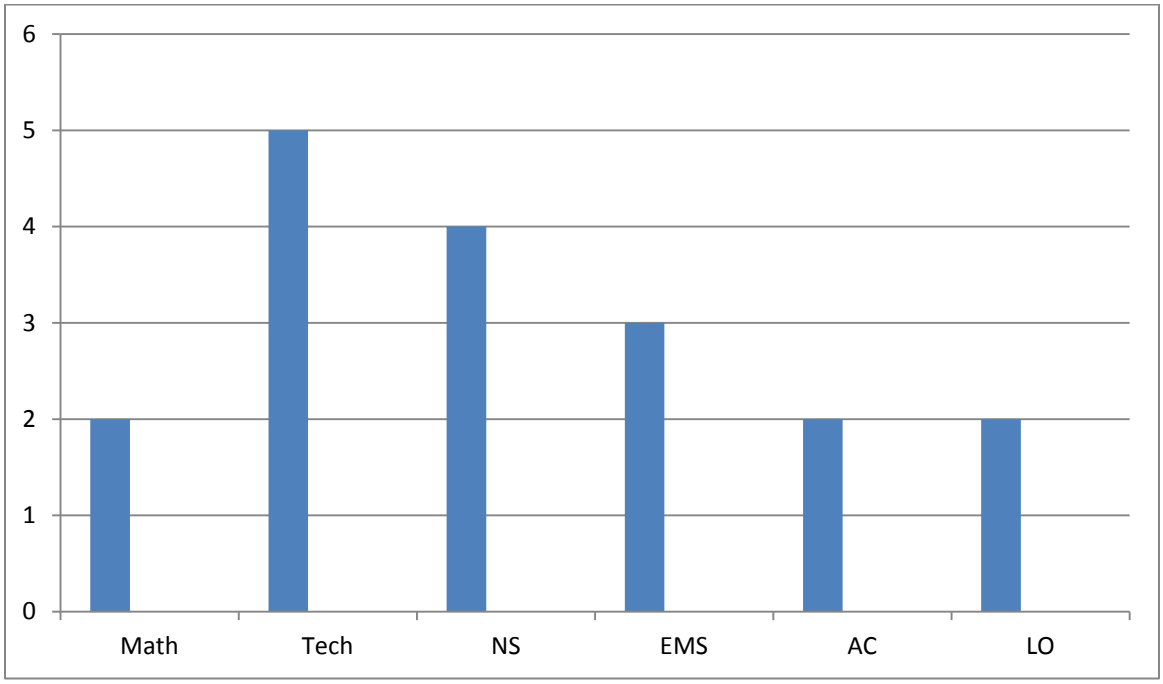
Next I examined the teaching workloads of the teachers to establish if they are teaching only EGD or whether they are also teaching in other learning areas. Information pertaining to these teachers' workloads is reflected in graph 4 below.



Graph 4: Number of teachers teaching EGD and other subjects

The data above shows that only 2 out of 13 teachers have a full workload of only EGD classes. The remaining 11 teachers of EDG are teaching other subjects to make up their work load. In essence, these teachers have to meet several sets of curriculum demands and CASS requirements, for EGD and for at least one other learning area.

So as to ascertain whether the other learning areas might be closely aligned to EGD, the subjects these 11 teachers teach in addition to EGD are reflected in graph 5 below.



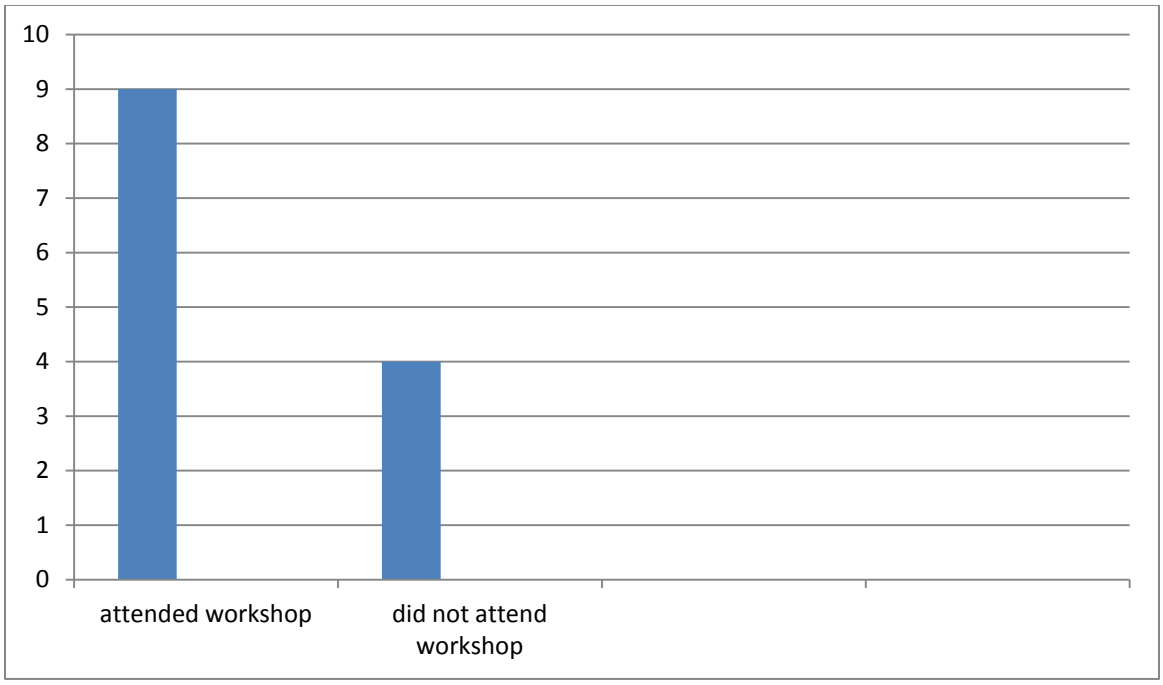
Graph 5: Additional subjects taught by EGD teachers

The diversity of curriculum requirements that these teachers are expected to be familiar with in their teaching and assessment is unveiled in graph 5. Some teachers even teach across more than two learning areas, depending on the schools PPN[1] (Post provisioning norm). One wonders how having to teach in additional learning areas, especially in those that one is not qualified to teach, impacts on these teachers' professional identity, the re-skilling and de-skilling they experience, and consequently, how it impacts on their understanding and teaching practice in AD. In a surreptitious way, this represents a never ending cycle. Because teachers have to teach across

[1] PPN: A ratio that determines the number of teachers a school is allocated. It is based on the number of learners enrolled at a school as per the schools 10th day enrolment figures. PPN impacts the subjects offered at a school and often requires teachers to teach other learning areas in addition to the subjects they are qualified to teach. (DoE, 2009).

several learning areas, there could be a negative impact on the effectiveness of their EGD lessons. There would then be less enthusiasm for EGD at the school, with poor uptake of technical subjects in the FET phase. Instead, had there been a greater uptake of EGD at these schools in the UThukela district these teachers' workload would consist of more periods of EGD, and they could then become better in this role.

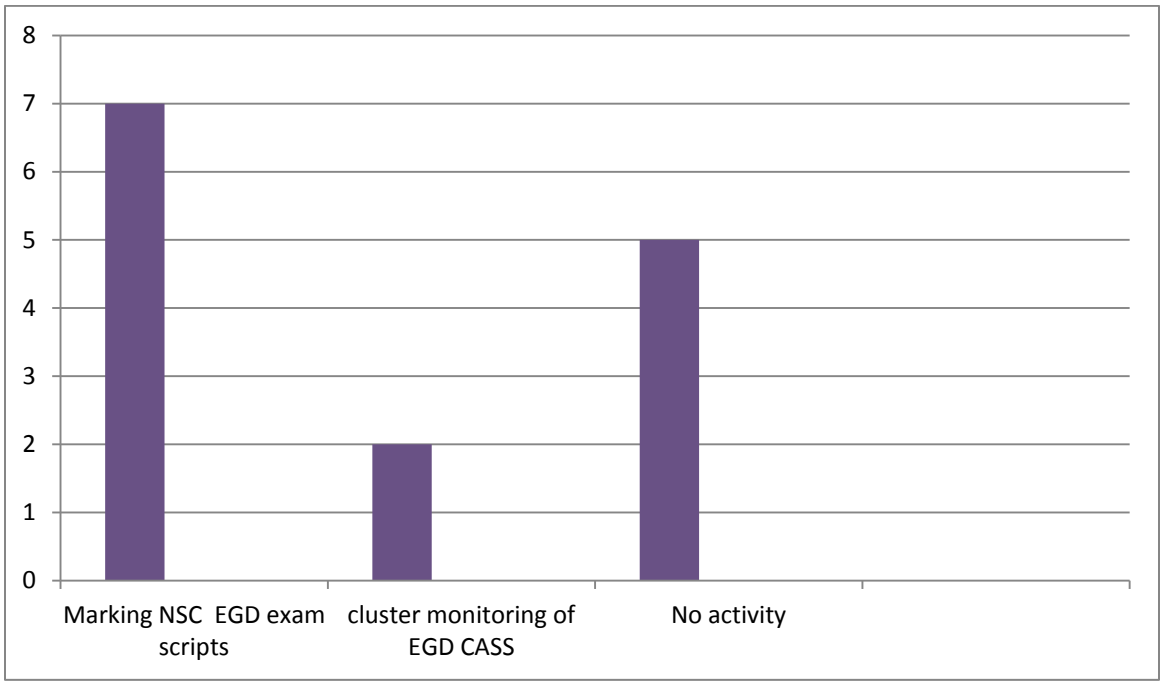
To be able to cope with the curriculum reform in EGD, practicing teachers of EGD are expected to attend the provincial department of education orientation workshops for curriculum implementation. Graph 6 below depicts information about teachers who attended these workshops.



Graph 6: Teacher information about attendance to workshop

Of the 13 EGD teachers, 9 had attended the workshops conducted by subject advisors for curriculum implementation, but 4 had not. The attendance or non-attendance of these workshops raises pertinent questions about these teachers understanding of AD, their teaching and assessment practice pertaining to AD, their implementation of the curriculum and the kinds of professional activities these teachers engage in.

The professional activities these teachers engage in pertaining to EGD is shown in graph 7.



Graph 7: Professional activities teachers engage in

From graph 7 it can be gathered that 9 teachers engage in some form of professional activity pertaining to EGD but 5 did not engage in any such activities. Seven teachers are involved in marking the NSC[2] EGD matric scripts and 2 teachers serve as cluster monitors of EGD teachers' CASS[3] portfolios. One teacher engages in both marking of the NSC EGD examination scripts and monitoring of EGD teachers' CASS portfolios. From such professional activities, EGD teachers have increased exposure to the EGD curriculum content and the assessment requirements. They also ought to become aware of the areas of weakness in learner performances in the NSC EGD examinations, through examiners and moderators reports and so these areas of weakness could and should be addressed. It stands to reason that the professional activity of these EGD teachers enhances their SMK (Rollnick, 2007) and sculpts their understanding of AD.

In summary, the biographical data from the teachers shows that only half are EGD qualified, and the TECH qualified teacher shave much less teaching experience. Nearly all of them teach across other learning areas, in addition to EGD. Nevertheless, most of the teachers attend

[2] NSC: National Senior certificate examination (matric examination)
[3] CASS: Continuous Assessment Portfolio

curriculum workshops and have engaged in professional activities that should enhance their understanding of EGD.

4.3. Part B: Research question one

The first research question: "What are Grade 11 EGD teachers' understanding of AD" is answered by using data from the questionnaire and focus group interviews. As mention earlier in section 3.9 the data collated to answer research question one was subjected to content analysis.

Content analysis of the text from the questionnaire and focus group interview reveals that Grade 11 EGD teachers' understanding of AD can be split into two key components; specifically, what it entails and the skills involved. The "what" component relates to the teachers' SMK and Skills component relates to the practical skills that are involved.

4.3.1. What AD entails and skills involved

From my data four categories emerge on what AD entails. These categories are a (re)presentation and an amalgamation of these EGD teachers' understanding of AD, their SMK, their learning style(s), the training they received to teach EGD as well as the professional activities they engage with in terms of EGD. The four emergent categories, listed as A-D, are illuminated in Table 6 below. The categories are arranged in a conceptual hierarchical order with category A being the lowest and category D being the most complex understanding of AD. The associated skills, as identified via the questionnaire and focus group interview, for each category are also reflected in the third column of the table.

Table 6: Teachers' ideas of what AD entails

Category	**Number of EGD teachers**	**Skills involved**
A. Putting components together	7	Physical –mechanical skills
B. Putting components to form a structure and draw it	3	Physical mechanical, manipulation, drawing
C. Putting mechanical parts, to facilitate an understanding of how they all function	2	Physical mechanical, manipulation, critical thinking
D. Involves visual reasoning, thinking of graphical images of mechanical components manipulating them and then putting it onto a diagram according to specifications	1	Visual reasoning, special perception, critical thinking,

The majority of the EGD teachers (seven) have a very basic or rudimentary understanding of what AD is or entails, as can be from the excerpts below:

"*It is just the putting together of components – you must not complicate this or you have to find a way to teach it – this is not a section I like*" T1 (Focus group interview-see appendix D2)

"*I don't like teaching this section, I don't understand it, learners perform poorly, for me is putting parts together – I'm surviving with this*" T5 (Focus group interview-see appendix D2)

Seven out of 13 EGD teachers construe AD merely as putting components together. These teachers see AD as a straight forward, mechanical process that entails a haphazard assembly activity.

Three EGD teachers perceive AD to be a process of putting components together in order to form a structure that needs to be drawn as reflected in the excerpts below:

"AD is putting things together to make a structure and you have to draw it" (T2-focus group interview, see appendix D2)

These three teachers have a slightly more advanced notion of AD. Their understanding of AD embraces three skills sets namely, the mechanical skills of putting objects together, manipulation of objects to form a structure and the ability to draw the structure assembled.

Two EGD teachers recognise AD as a process of putting together mechanical components in order to understand how they function together, as can be seen in the excerpt below:

"*It's putting together mechanical component only, seeing that they function and then drawing it"* (T 13, focus group interview, see appendix D2)

This means that AD involves the putting together of not just any components but specific mechanical components, manipulating them so that the machine can function optimally. The manipulation of parts to ensure optimal functioning will involve critical thinking.

Only one EGD teachers has a deep understanding of AD as shown in the excerpt below:

"It is not as easy or straightforward as they are making it, it's a complex process, it does involve assembling or sectioning of mechanical components, visualizing 3D parts from 2D drawings, visually manipulating them as per specification and construction the diagram, you must also know your lines and codes" (T7, focus group interview, see appendix D)

This particular teachers' understanding of AD embraces the notion of visual reasoning, thinking of graphical images of mechanical components, manipulating them into different projections, and lastly drawing them according to specifications. This teacher's understanding of AD includes visual reasoning, special perception and. critical thinking.

4.3.2. Summary

The research data showed 4 core understanding of AD among Grade 11 EGD teachers, indicating a hierarchy of sophistication; (i) putting components together, (ii) putting components together to form a structure and draw it, (iii) putting mechanical parts to facilitate an understanding of how they all function and (iv) involves visual reasoning, thinking of graphical images of mechanical components manipulating them and then putting it onto a diagram according to specifications. The finding and discussion in section 4.3.1.above supports the idea that these EGD teachers' understanding of AD is shaped by their learning style, subject matter knowledge (SMK), the training received to teach as well as the professional activities they engage in (Zeidler, 2002). Subject matter knowledge refers to the teacher's understanding of the subject content she/he teaches (Gudmundsdottir, 1987, p. 6). Research by Wilson and Winberg, (1988) confirms that a teacher's understanding of a phenomenon impacts how accessible the subject matter knowledge is to him/her as well as how he/she engages with the subject material. The type/kind of initial teaching training received and the consequent type of professional development received will either enhance subject matter knowledge or have no effect of SMK.

4.4. Part C Research question two

The second research question: "What are Grade 11 EGD teachers' practice of AD?" is answered by using data from the questionnaire, focus group discussion and observations. Data generated was analysed in stages using the thematic methods, as was outlined in section 3. 9

4.4.1. Findings from questionnaire and focus group interview on Grade 11 EGD teachers' practice of AD

From my data three themes emerge on Grade 11 EGD teachers' practice of AD, as can be seen in table 8 below.

Table 8: Grade 11 EGD teachers' practice of AD

Themes	Number of teacher
Chalk and talk (drawings on board / charts)	10
Lecture method and teacher demonstrations	2
Demonstrations, hands on activities, projects	1

As can be seen in the data above, only three teachers engage in teaching styles beyond traditional 'chalk and talk'. Each of these categories are discussed below.

4.4.1.1. Chalk and talk

From table 7 it evident that ten Grade 11 EGD teachers rely solely on the traditional chalk and talk method to teach AD. They painstakingly draw diagrams on the board or make charts to illustrate AD to their learners. As part of the analysis process I traced these 10 EGD teachers' practice of AD to their understanding of AD, their qualification and the professional activities they engage in, this tracing is reflected in table 9 below.

Table 9: Qualification, professional activity and understanding of AD for the 10 "chalk and talk" teachers

Category	Number of teachers
Qualification:	
Technology education qualification	7
EGD qualification	3
Professional activities:	
No engagement in professional activities	5
Marking of NSC RGD exam papers	5
Attendance at training for curriculum implementation:	
Number attended training	6
Number that did not attend training	4
Understanding of AD	
Putting components together	7
Putting components to form a structure and draw it	3

Please discuss table 9: what patterns does it show? It seems to me that these teachers are attempting to further themselves professionally, but have not formal EGD qualification, and generally low concept of what AD entails.

As indicated earlier in section 3.6.2.3. the semi structured observation schedule focused on the physical setting, human setting, programme setting and the lesson. I first present a description of each of these setting before I begin with the discussion

Physical setting

School A is located in a semi-rural area, the roads leading to the school are untarred. I arrive at the school gate at 9am. There are many learners outside the school gate. The school is surrounded by a wire fence and a teacher opens the gate when the cleaner, who also acts as a security guard, is busy elsewhere in the school. The school has a soccer /sport ground and many learners are outside playing soccer, whilst the school academic program is in session. The school is built of bricks, it has electricity and water. The quintile ranking of this school is 1. The school has a library, science laboratory and EGD room but these specialist rooms lack the necessary equipment to make them fully operational. Each classroom is fitted with a chalkboard but they lack furniture to accommodate all the learners in class. Learners share textbooks. Teachers carry their chalk with them as they move from class to class. The school does have five OPHs but these are non-functional as the bulbs have burnt out.

Human setting

School A has a principal, two deputy principals, three heads of departments and a staff of 23 level one teachers. The school has an enrolment of 950 learners. The official medium of instruction at school A is English. The learners are mostly isiZulu speaking and a few learners speak other African languages. The EDG teachers home language is isiZulu, he uses a mix of English and isiZulu in this EGD classroom. Learners also use a mix of English and isiZulu in the EGD class. I observed a Grade 11 EGD class comprising 20 boys. These learners walk to school.

Programme setting

The NCS-CAPS curriculum is the official policy being followed at this school. This curriculum embraces a learner-centered approach to teaching and learning. During the pre-observation interview the teacher had indicated that he was going to teach orthographic projects by first and third angle methods using a chart and a model to demonstrate and learners would be involved in hands-on activities. During the lesson the teacher uses a teacher dominated approach to teaching. There is very little room for learner engagement with the "content", there are few or no opportunities for learners to engage with what is drawn on the board. Learners have to copy what's on the board and their drawings are assessed according to the degree of replication to the drawing on the board. Coincidentally, the NSC EGD pass rate at this school is below 50%. An examination of the teacher's master portfolio shows that this particular EGD teacher does not use the EGD CAPS curriculum to plan his teaching and learning, so there is limited transfer of curriculum content to context. The aims of the lessons are not aligned to the goals of the curriculum – the teacher does not foreground orthographic projection, sectioning, use of drafting conventions, dimensioning, pictorial views and sketching in his lessons. The pace of the lesson and learning is hindered by the teachers' practice of drawing on the chalkboard. An examination of the learners CASS portfolio reveals that no feedback is provided to learners on their replicas of the teachers' drawings, nether are learners provided with a rubric to guide them during their assessment. The atmosphere in the classroom was rigid with no room for learner engagement or creativity. After my observation of the lesson I asked the teacher if he was going to be available for the post observation interview he stated he had changed his mind as he does not want an inquiry into his teaching. My discussion is therefore based only on the focus group discussion and observation.

Data from the focus group interview and observation reveal the rationale for the teachers' preferred practice of "chalk and talk" in terms of AD.

"I draw on the board learners can see how I'm drawing and they can follow in their pages, do you know how long that takes, sometimes the whole period is spend drawing on the board and the next day the learners will just copy the diagram and see how you put parts together, they must learn to copy, I don't like using OHP then the parts are assembled and the learners can't see how to put them together" (T1, focus group interview see appendix, D2)

"There are no models, so I have to draw on the board and learners copy how to put components together and practice drawing, this is not the only subject I'm teaching two other subjects, I'm trying to survive here, the training we get to implement this CAPS is so poor, the trainer needs training, I have no time to go and get models from scrap yards, they just follow, there is no thinking here only coping drawings, hey they don't keep quiet when I'm busy drawing, these learners are so rude" (T4, focus group interview see appendix D2)

"We need auto cad to help, but we don't have it at my school so I do what I think is right, the training we receive is poor, it don't show us how to teach AD, in this training we need hands on training not a theory lesson on what should be done, I draw and learner copy or they trace from my drawings on worksheets" (T8 , focus group interview, see appendix D2*)*

The interplay between these ten Grade 11 EGD teachers' CK/SMK, knowledge of the curriculum, their knowledge of how learners come to know (*there is no thinking here, just copying*), their teaching practice (PK) and contextual conditions gets illuminated via the above excerpts. The contextual factors (*no models, teaching other subjects, don't like using OHP, lack of time, poor training*) as well as these teachers' CK or SMK of AD (*put parts together, put components together*) gets illuminated via their practice. What can be seen in the above excerpts is how these ten Grade 11 EGD teachers (re)present) their content knowledge so that it can be "accessible" to the particular learners in their classroom. These teachers' CK/SMK is not sequenced or graded into tasks for learners (*they just copy, there is no thinking here only copy drawings, trace from my worksheets*), learning and assessment. For example, they do not use their drawings to instruct the sequence, orientation and positions of components in the assembly

task. They are not specific about the graphical style they used, in other words is it orthographic or isometric drawings. Their "teaching strategy" is teacher centered (*they can follow*, *learners copy*, *copy the diagram*) and is does not espouse the learner-centered philosophy of the NCS CAPS curriculum. These teachers' practice begs the question: How cognitively stimulating is copying without deep understanding and exposure to the discourse of AD? The preceding finding resonates with that of Adler et al. (2002) and Rusznyak (2010), which together confirm that teachers' PK is linked to their CK/SMK, knowledge of the curriculum and knowledge of how learners come to know, however my findings also illustrate the impact of the school ecology (contextual factors) and professional activities that teachers engage in. In other words the above findings confirm that teachers' practice is a blend of CK/SMK, knowledge of the curriculum, training received for curriculum implementation, beliefs about learning, professional activities and school ecology.

4.4.1.2. Lecture method and teacher demonstration

Table 7 reflects that two Grade 11 EGD teachers use the lecture method and teacher demonstrations as their teaching practice for AD. In subscribing to the lecture method and teacher-led demonstrations these teachers do not espouse the learner-centred philosophy of the NCS CAPS in their practice. As mentioned earlier, I traced these two teachers' practice of AD to their understanding of AD, their qualification and the professional activities they engage in, this tracing is depicted in table 10 depicts below.

Table 10: Qualification, professional activity and understanding of AD for "lecture method and demonstration" practice

Category	Number of teachers
Qualification:	
EGD qualification	2
Professional activities:	
Marking of NSC RGD exam papers	2
Cluster monitor of CASS portfolio	1
Attendance at training for curriculum implementation:	
Number attended training	2
Understanding of AD	
Putting mechanical parts, to facilitate an understanding of how they all function	2

As can be seen, both of these teachers are EGD qualified, they are involved in further professional activates and have a relatively high understanding of what AD involves.

The findings from the observation are reflected below and then the discussion follows.

Physical setting

School B is located in a semi-rural area, the roads leading to the school are tarred. I arrived at the school gate at 8:30 am. The school is surrounded by a palisade fence and the area around the school is free of litter. There are no learners loitering outside the school fence. A security guard opens the school gate to grant me access into the school. I was required to complete the visitor's information record book before I could enter the school. The school is in session and there are no learners outside the classrooms. The principal of the school is visible as he walks around from class to class checking on learners' attendance. The school is built of bricks, it has electricity and water. The quintile ranking of this school is 2. The school has a library, science laboratory and EGD room but with the bare minimum of equipment. Each classroom is fitted with a chalkboard. The desks in the classrooms are arranged in groups of 4 to facilitate sharing of textbooks. There

are a few models in the EGD workshop that are sourced from the local scrap yard by the teacher. There are also charts made by the teacher that represent the machine symbols, conventions, various types of lines.

Human setting

School B has a principal, one deputy principal, four heads of departments and a staff of 20 level one teachers. The school has an enrolment of 850 learners. The official medium of instruction at school B is English. The learners are mostly isiZulu speaking and a few learners speak other African languages. The EDG teachers' home language is isiZulu, he mainly uses a English in his EGD classroom, but sometimes uses isiZulu to help his learners grasp what is said. I observed a Grade 11 EGD class comprising 25 boys. These learners are neatly attired in full school uniform and walk to school.

Programme setting

The NCS-CAPS curriculum is the official policy being followed at this school. This curriculum embraces a learner-centered approach to teaching and learning. During the pre-observation interview the teacher had indicated that he was going to teach, via demonstrations and a lecture method, the use of elementary standard practice, conventions, abbreviations and machine symbols, the use of part sections to show machine details. Co-incidentally the NSC EGD pass rate at this school is above 60%. An examination of the teacher's master portfolio shows that this particular EGD teacher uses the EGD CAPS curriculum to plan his teaching and learning, so there is transfer of curriculum content to context. The aims of the lessons are aligned to the goals of the curriculum – the teacher has foreground orthographic projection, sectioning, use of drafting conventions, dimensioning, pictorial views and sketching in his lessons. The pace of the lesson and learning is aligned to the KZN DBE work schedule provided to teachers. An examination of the learners CASS portfolio reveals that they are provided with multiple opportunities to engage with NSC exam type questions. The atmosphere in the classroom was relaxed and learners ask questions.

During the post observation interview this EGD teacher highlights the lack of resources to justified his use of lectures and teacher-led demonstrations to teach AD. This method seems to be working as the learners' pass rate and quality of passes in the NSC EGD exams has improved.

The factor that promotes my teaching and inspires me to teach is the learners' willingness to try to improve their performance. I enjoy teaching EGD and AD. In an ideal context my teaching will be difference – more hands on.

Data from the focus group interview reveals the rationale for the teachers' preferred practice in terms of AD.

"*I use teacher demonstration due to time constrains and there being not enough models to let student engage in hands on activities, but in this way learners can see how to put these machine parts and understand how they work, then they draw, I try my best, with all the challenges we encounter in our schools, discipline issues, poor attendance*" (T8 - focus group interview, see appendix D2)

"the lecture method coupled with demonstration work well, resources are hard to come by here – as I explain what is expected of the learner in the exams and then demonstrate what must be done and explain why it must be done. "(T13 focus group interview, see appendix, D2)

The excerpts above make overt the interaction between these two teachers' CK/SMK (*how to put these machine parts and understand how they work, then they draw),* knowledge of the curriculum (*is expected off the learner in the exams*), their teaching practice (*teacher demonstration, lecture method*) and contextual conditions (*time constrains,. discipline issues, poor attendance, resources are hard to come by*), the contextual factors (*time constrains, lack of models/resources, discipline issues, poor attendance*) drives and sculpt these two teachers' teaching practice of AD. The above data confirms that context determines what is possible in terms of teaching practice.

4.4.1.3. Demonstrations and learner hands on activities/projects

Table seven reflects that one Grade 11 EGD teacher engages in demonstrations and learner hands-on activities/projects as his/her teaching practice of AD. This teacher's understanding of AD, qualification and the professional activities he/she engages in can be seen in table 11 below.

Table 11 Qualification, professional activity and understanding of AD for demonstration and hands on practice

Category	Number of teachers
Qualification:	
EGD qualification	1
Professional activities:	
Marking of NSC RGD exam papers	1
Cluster monitor of CASS portfolio	1
Attendance at training for curriculum implementation:	
Number attended training	1
Understanding of AD	
Involves visual reasoning, thinking of graphical images of mechanical components manipulating them and then putting it onto a diagram according to specifications	1

The information above indicates that this teacher is qualified to teach EGD, is involved in professional activities such as marking and cluster monitoring of CASS portfolio and attended the training workshop for implementation of the EGD CAPS curriculum.
The findings from the observation of this teacher are reflected below and then the discussion follows.

Physical setting

School C is located in a town, the roads leading to the school are tarred. I arrived at the school gate at 11 am. The school is surrounded by a palisade fence, the area around the school is free of litter and has a well maintained garden with shrubs and pretty flowering plants. A security guard opens the school gate to grant me access into the school. I was required to complete the visitor's information record book before I could enter the school. The car park is large and spacious. Many sport fields are visible from the car park. There is a tennis court, basketball court, swimming pool and soccer/rugby field. At the reception area I was required to fill in the visitors' book before I was introduced to the principal. This principal allowed me the use of the deputy principal's boardroom to conduct my pre-observation interview. The school has quintile ranking of 4. This is an ex model C school and is well resourced. The school has a fully equipped and functional library, science laboratory, computer room and EGD room. Each specialist room is

fitted with an air conditioner, data projector and chalkboard. Each learner has access to the schools wi-fi. There are many models, purchased charts on AD in the EGD workshop

Human setting

School C has a principal, two deputy principals, four heads of departments, 20 level one state appointed teachers and 10 governing body appointed teachers. The school has an enrolment of 850 learners. The official medium of instruction at school B is English. The learners are mostly isiZulu speaking. The EDG teachers' home language is isiZulu, she mainly uses English in her EGD classroom. I observed a Grade 11 EGD class comprising 20 boys and 2 girls. These learners are neatly attired in full school uniform and many of them travel by private transport to school. .

Programme setting

The NCS-CAPS curriculum is the official policy being followed at this school. This curriculum embraces a learner-centered approach to teaching and learning. During the pre-observation interview the teacher had indicated that she was going to teach via demonstrations and a mini hands-on project, the drawing of pictorial views of a machine in accordance with SANS. The NSC EGD pass rate at this school is above 78%. An examination of the teacher's master portfolio shows that this particular EGD teacher's teaching and learning outcomes are aligned with that of the CAPS EGD curriculum. There is maximum transfer of curriculum content to context. The aims of the lessons are aligned to the goals of the curriculum – the teacher has foreground orthographic projection, sectioning, use of drafting conventions, dimensioning, pictorial views and sketching in her lessons. There is ample evidence of rigour in the assessment tasks given to learner. Learners are provided with many chances to master the skills required to excel in AD and the assessment tasks consist of higher order questions as well. The pace of the lesson and learning is aligned to the KZN DBE work schedule provided to teachers. An examination of the learners CASS portfolio reveals that they are provided with detailed feedback on all their assessment tasks to help them identify their areas of weakness and scaffold their learning. The atmosphere in the classroom is relaxed and learners worked in group and ask freely for feedback on their projects. The teacher actively encourages learner to ask questions while their engage in hands on activities. This EGD teacher facilitates learning.

During the post observation interview this EGD teacher highlighted and justified her preferred method of teaching AD: hands on project work as it allows for learning by doing, stimulates curiosity, and learner creativity. This method works as the learners pass rate and quality of passes in the NSC EGD exams is improving each year. The aim is to obtain a 100 % pass rate with high quality passes. Teaching is my vocation of choice, I'm passionate about teaching EGD and I want to make a difference in the lives of EGD learners.

Data from the focus group interview reveals that this particular Grade 11EGD teacher embraces a learner centered approach in her teaching practice of AD.

"*Learners have great difficulty in visualizing objects in 3D. In the absence of this skill it is hard to draw different views of an object. Learners are expected to do this in the exams, Therefore I demonstrate these views by sectioning models, get learner to assemble parts in group, then draw the various views, I also give them the past year exams questions, so they know what is required in AD, they must be able to get all the taken for granted marks in the section, I provide detailed feedback on their drawings so they know what they did wrong .*" (T7,focus group interview-see appendix D2)

The synchronicity between this particular Grade11 EGD teachers' CK/SMK, knowledge of the curriculum, personal knowledge, ontological commitment, assessment practice, difficulties learners encounter and their teaching practice of AD is elucidated via the above excerpt. The above finding demonstrates that PCK is a combination of the aforementioned factors.

4.4.2. Summary

Grade 11 EGD teachers use three practices to teach AD, namely, chalk and talk, lecture method and teacher-led demonstrations as well as demonstrations, hands on activities or projects. My findings illustrate the intrinsically intertwined relation between CK/SMK, knowledge of the curriculum, professional activities, training received for curriculum implementation, contextual factors and teachers' practice (PK).

4.5. Part D Research question three

The third research question: "Is there an interface between Grade 11 EGD teachers' understanding of AD and their practice of AD? If so, what is the nature of the interface?" is answered by first juxtaposing data from research questions one and two and then (re)assembling data from the questionnaire, focus group interview and observation to describe the nature of the interface. As mentioned in chapter 2 to bring to the fore the interplay between teachers' understanding of AD and their practice of AD I draw on Singh-Pillay's (2010) notion of interface. According to Singh-Pillay (2010), interfaces arise out of the points of convergence and divergence between the elements or people's views. It is this notion that is applied in this study. The concept of an interface is construed as a meeting point (convergence) or a point of deviation (divergence) between teachers' understanding of AD and their practice in terms of AD.

4.5.1. Is there an interface?

This question was answered by juxtaposing the four categories of Grade 11 EGD teachers' understanding of AD (see section 4.3.1.) with the three themes on Grade 11EGD teachers' practice of AD. Figure 4 below reflects this juxtaposing of findings.

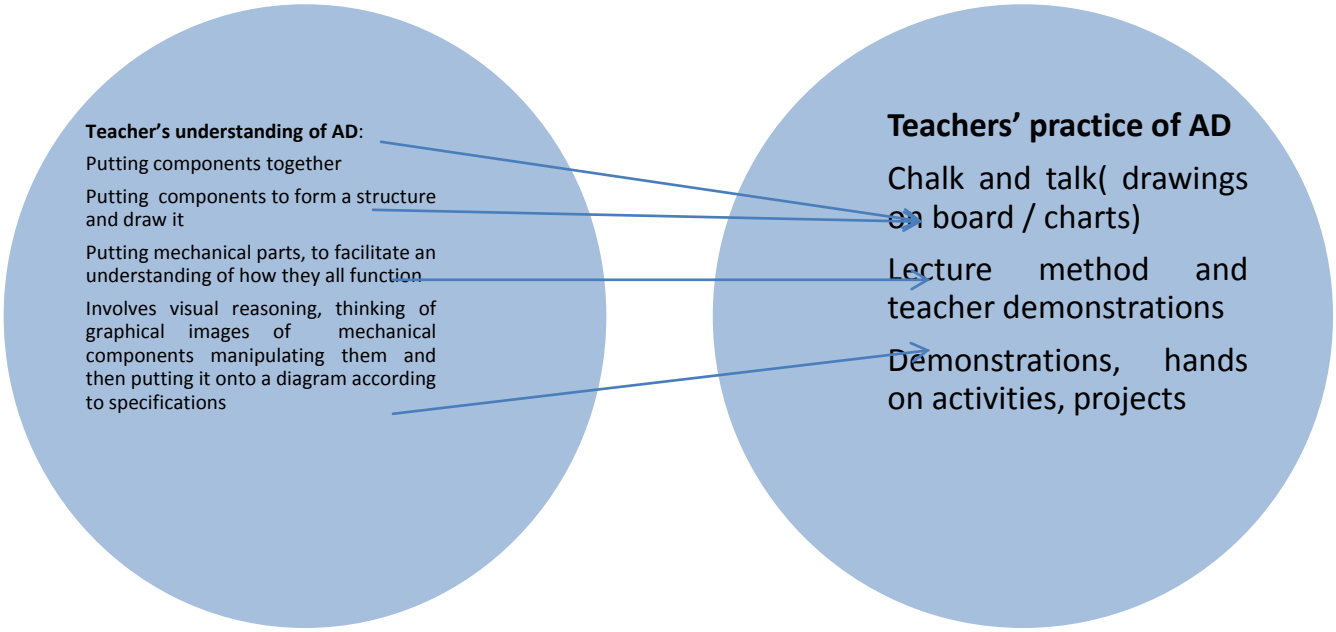


Figure 4: Juxtaposition of Teachers' understanding of AD and teachers' practice of AD

Figure 4 shows that an interface does indeed exist between Grade 11 EGD teachers' understanding of AD and their practice of AD. Two categories of understanding of AD (putting components together and putting components to form a structure and draw it) converge with the practice of AD as chalk and talk. The understanding of AD as putting mechanical parts, to facilitate an understanding of how they all function corresponds with the practice of AD as a lecture method and teacher demonstrations. The last understanding of AD, (involves visual reasoning, thinking of graphical images of mechanical components manipulating them and then putting it onto a diagram according to specifications) matches the practice of AD as demonstrations, hands on activities and projects. From figure 4 above it can be inferred that there were no divergences between these Grade 11 EGD teachers' understanding of AD and their practice of AD. In other words, there appears to be 100% convergence or alignment between these teachers' understanding of AD and their practice of AD. There are three interfaces that emerge between teachers' understanding of AD and their practice of AD as reflected in table 12 below.

Table 12: Interfaces between teachers understanding and practice of AD

Teachers' understanding of AD	Teachers' practice	Interface number
putting components together putting components to form a structure and draw it	Chalk and talk	one
putting mechanical parts, to facilitate an understanding of how they all function	lecture method and teacher demonstrations	two
involves visual reasoning, thinking of graphical images of mechanical components manipulating them and then putting it onto a diagram according to specifications	demonstrations, hands on activities and projects	three

4.5.2. The nature of the interface

To illuminate the nature of the three interfaces identified in the preceding section I (re)assembled the data obtained from the questionnaire, focus group discussion and observation. This means that the nature of the interface is characterised by the associations amongst biographical data, qualification, professional activities, training for curriculum implementation, school ecology (context) and teachers' professional agency as reflected in table 13 below.

Table 13: (Re) assemblage of data to illuminate factors that shape the nature of the interfaces

	Interfaces		
	One	**Two**	**Three**
(Re)assemblage			
Teacher who studied EGD at school	3	2	1
Teachers with a qualification in EGD	3	2	1
Teachers with qualification in technology education	7	0	0
Teachers teaching EGD only at	0	1	1
Teachers teaching other learning areas +EGD	10	1	0
Teachers attended training workshop for EGD CAPS implementation	6	2	1
Teachers who did not attend training for CAPS implementation	4	0	0
Professional activities: cluster monitor for CASS	0	1	1
Professional activity: Marking of NSC EGD exam scripts	4	2	1

Quintile ranking of school	1 & 2	3	4
Availability of resources	Not available /challenge to get resources	Limited resources- much of it sourced by teacher	Readily available- well resourced
Support within school ecology	Nil	Very little	Great

From table 11 the factors that shape the nature of the interfaces between teachers' understanding of AD and their practice of AD become conspicuous. As one moves across the table from interface one to interface three the degree to which these factors inhibit or promote teachers' understanding of AD and their practice of AD becomes visible. Interface one can be attributed to many (7) of these EGD teachers not having a qualification to teach EDG, 10 teachers having to teach EGD in addition to other learning areas, 4 teachers not attending the EGD-CAPS training for policy implementation, only 4 teachers being involved in professional activities, all 10 teachers having to teach at schools with quintile ranking 1 or 2, there being a lack of resources at these schools and no professional support being available from within the school ecology. These factors have a direct bearing on these teachers' CK, SMK and hence their PCK. Their lack of a deep conceptual and cognitive understanding of AD impinges on their practice of AD.

Interface two shows that these teachers have a foundational background in EGD (they studied EGD at school) which created a cognitive platform for their engagement of EGD at a tertiary level. In addition these two teachers have attended the EGD-CAPS training for policy implementation and are engaged in professional activities pertaining to EGD. Furthermore there two teachers are teaching at schools where they receive support from within the school structure for their professional development and their practice (see physical setting in section 4.4.1.1. for discipline ethos of the school).

Interface 3 confirms the interplay between the factors the shape and sculpt teachers' understanding of AD and their practice of AD. This particular EGD teacher studied EGD at school and pursued a qualification in EGD. Additionally, she is actively involved in professional activities such as marking NSC-EGD examination scripts and monitoring EGD teachers' CASS portfolios, which all impact her awareness of the EGD curriculum content, its philosophy, teaching and learning requirements, and assessment criteria. Furthermore she receives both

physical and human resources support from within her school structure (see physical, human setting in section 4.4.1.3.).

My findings resonates with that of Alonzo, (2002) who demonstrates that in mathematics, teachers who understood multiple representations of mathematics concepts were able to use these representations to further students' understanding via their teaching practice. This means that teachers with deeper content knowledge were more likely than those with weaker knowledge to engage learners in meaningful learning through their classroom room activities and teaching strategies (Alonzo, 2002).

From the aforementioned discussion it can be gleaned that the nature of these three interfaces differs. These interfaces are shaped and sculpted by a variety of factors. In other words, the nature of the interface evolves in accordance to the contextual factors that impinge on, or advance, teachers' understanding of AD and their practice of AD. Put simply, it means that these three interfaces are specific to the context of this study and its sample of EGD teachers. Should this study be replicated in another region it is possible that the nature of the interface may differ.

4.5.3. Summary

My findings reflect that three interfaces do indeed exist between Grade 11 EGD teachers' understanding of AD and their practice of AD. The nature of these interfaces is shaped and sculpted by factors such as teacher qualification, training received for implementation of the EGD CAPS curriculum, professional activities as well as support within the school structure. The impact that teachers' understanding of AD has on their practice of AD is exposed. My finding points to the need to improve Grade 11 EGD teachers' CK and SMK pertaining to AD in order to improve their practice. Simply put, this means that for AD learning to be effective and successful, the EGD teacher should be able to understand and master both the AD content and its didactics.

4.6. Conclusion

In this chapter I aimed to answer the three research questions posed by this study.

To answer the first research question (What is Grade 11 EGD teachers' understanding of AD?) I engaged in content analysis of data from the questionnaire and focus group interviews. The

analysis highlights that Grade 11 EGD teachers had four core understanding of AD: viz, putting components together; putting components to form a structure and draw, putting mechanical parts, to facilitate an understanding of how they all function and involves visual reasoning, thinking of graphical images of mechanical components manipulating them and then putting it onto a diagram according to specifications.

Data from the questionnaire, focus group interview and classroom observation were used to answer research question two (What is Grade 11 EGD teachers' practice of AD?). This data was subjected to thematic analysis which revealed that Grade 11 EGD teachers have three preferred practices of AD, viz, chalk and talk, lecture method and teacher demonstrations, and demonstration with hands on activities and projects.

To answer the third research question (Is there an interface between Grade 11 EGD teachers' understanding of AD and their practice of AD? If so, what is the nature of the interface?) I drew on Singh-Pillay's (2010) notion of interface. Data from the two earlier research questions were juxtaposed and data from the questionnaire, focus group interview and observation were (re)assembled in order to establish if any interface/s existing between Grade 11 teachers' understanding of AD and their practice of AD, and to describe the nature of the interface. My findings confirm that interfaces do exist between teachers' understanding of AD and their practice of AD. The nature of the interface is sculpted by teacher qualification, teacher professional activities pertaining to EGD, training received for implementation of the EGD CAPS curriculum, teachers' CK/SMK, resources and support received from within the school.

The findings of this study lead me to the question: how can teachers take ownership for curriculum implementation in the absence of adequate training and resources for implementation and in poor school ecologies? In the last chapter, I discuss the implications of the findings of this study for teacher professional development and the development of professional learning communities.

CHAPTER 5

Conclusions and recommendations

5.1 Introduction

The purpose of this study, as mentioned earlier in chapter one, was twofold. First it sought to explore grade 11 EGD teachers' understanding and practice of AD. Second it wanted to explore if an interface existed between these teachers' understanding of AD and their practice of AD and then to describe that nature of the interface should it exist. A case study approach was used to collect data in the uThukela District from Grade 11 EGD teachers. Data was collected in four phases using a questionnaire, focus group interview and classroom observations. Once it was collated, data was subjected to content and thematic analyses. The analysis of the data collected to answer research question 1 illuminated that Grade 11 EGD teachers had four primary ways of understanding AD, namely: putting components together; putting components to form a structure and draw; putting mechanical parts to facilitate an understanding of how they all function; and involves visual reasoning, thinking of graphical images of mechanical components manipulating them and then putting it onto a diagram according to specifications. Each understanding also reflects the skills and processes required to engage in AD. Data analysis for research question 2 unveils the grade 11 EGD teachers' practice of AD as being chalk and talk, lecture method and teacher demonstrations or demonstrations with hands on activities and projects. The data from research questions one and two were juxtaposed and (re)assembled to answer the third research question. My findings indicate that these Grade 11 EGD teachers' understanding of AD does interface with their practice of AD. The nature of the interface indicates that teachers with deeper content knowledge, greater support and more active engagement in professional activities were more likely to engage learner in meaningful learning via their classroom room activities and teaching strategies, than were those with weaker knowledge, less support and minimal engagement in professional activities.

In this chapter I reflect on the implications of this study. I also outline recommendations that are based on the findings for appropriate teacher professional development and suggestions for further research are presented.

5.2 Implications of this study

5.2.1 Reflective practice

In this section I look at the intricate, intertwined relationship between teachers' practice and reflection. Essential improvements to the quality of teaching and learning are more likely if teachers make a concerted effort to reflect on their practice. (Kane, Sandretto, & Heath, 2002). In this study, reflection entails purposively thinking about actions taken in relation to teaching AD in order to develop a more nuanced understanding and practice of AD. Reflection on action clarifies or establishes an explicit link between teachers' knowledge and classroom practice and allows the teacher to explore factors that facilitate or impede the enactment of PCK in the classroom. By engaging in reflection teachers can re-examine their personal conceptions of teaching and learning of AD that seemingly have an influence on how they teach, which also influence their learners' approach to learning and in turn affect learning outcomes (Ohemeng-Appiah, 2014).

5.2.2 Professional development

If change is to be sought at the coal face, then there is a dire need for teacher training tertiary institutions to offer pre-service teacher preparation programmes in EGD. The biographical data from this study elucidates that teachers teaching EGD for less than 10 year do not have a qualification in EGD, but instead they have a qualification to teach technology education. In the absence of an effective pre-service EGD teacher preparation programme tertiary institutions have an obligation to provide ongoing professional development programmes for in-service teachers to upgrade or reinforce their content knowledge, specifically conceptual knowledge in EGD. A deep understanding of the content and how to teach it is crucial to enhance the teachers' classroom practice or pedagogy.

5.3 RECOMMENDATIONS

In line with the findings of this study some recommendations have been outlined to improve teachers' understanding and practice of AD. The recommendations relate to curriculum

implementation, professional development of teachers, research, and formation of professional learning communities.

5.3.1 Curriculum implementation

Curriculum implementation hinges on teachers, therefore it is imperative for teacher to receive and experience the kind of “hands on” learning advocated by the CAPS policy for curriculum implementation rather than the “once off – just in time” theoretical lecture mode of training (Singh-Pillay & Alant, 2015). The DBE needs to pay closer attention to the training it offers to teachers for curriculum implementation.

5.3.2 Professional development

Based on the findings of this study I decided to propose a teacher professional development intervention (PDI) programme to enhance teaching and learning of AD in the uThukela District. It is also hoped that this PDI programme will forge links between EGD teachers in the district and so develop professional learning communities. This model will serve to assist EGD teachers in this region, as this is the target for the case study. According to Guskey (2002) a PDI programme has five outcomes: improvement in teachers’ CK or SMK, change in the classroom practice of teachers, change in the attitudes and beliefs of teachers, development of professional learning communities and change in the learning outcomes of learners. The PDI programme I proposed is reflected in figure 5 below. Stages 1, 2 and 6 are aimed at improving teachers’ CK/SMK on AD, Stages 3 and 6 are aimed at changing the classroom practice of teachers, stages 4 and 6 target a change in the learning outcomes of learners and stage 5 is designed to bring about a change in attitude and belief of teachers as well as led to the development of professional learning communities amongst these teachers.

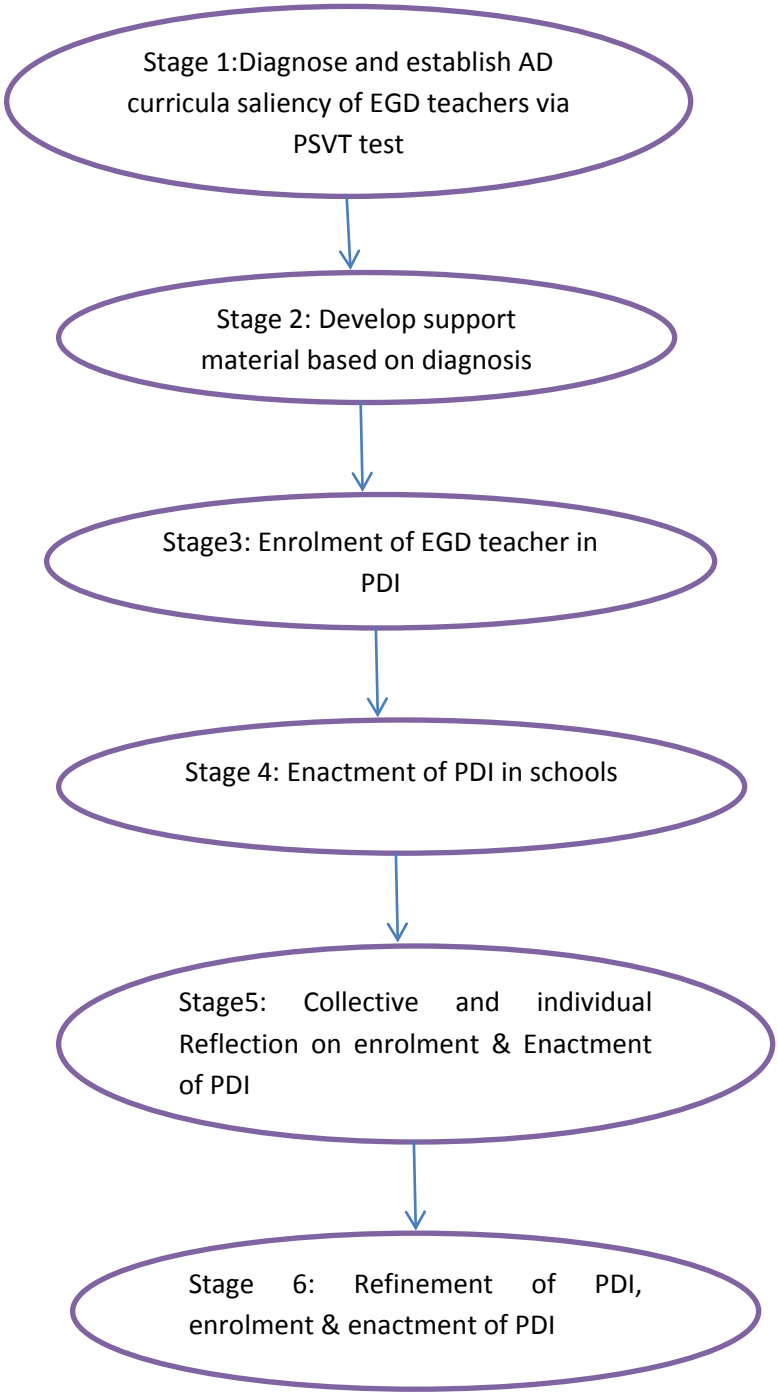


Figure 5: Stages of the proposed PDI

5.4. Recommendations for further research

Further research should be conducted to ascertain the relevance and effectiveness of current teacher training programmes in EGD in South Africa.

The frequency and effectiveness of EGD teacher workshops should also be researched, in order to identify ways of making them more effective for the benefit of teachers, learners and all stakeholders of education. This study should involve the subject specialist as well as the subject teachers themselves.

5.5. Conclusion

The findings of this study clarify that interfaces do exist between grade 11 EGD teachers' understanding of AD and their practice of AD, and that the nature of the interface is shaped by factors such as teacher qualification, knowledge of the curriculum, training for curriculum implementation, professional activities, school ecology and resources. At a theoretical level the challenge is to change the nature of the interface and so improve the CK, SMK AND PCK of the EGD teacher.

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APPENDICES

A1: ETHICAL CLEARANCE

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

12 August 2015

Mr Douglas Thembinkosi Sibusiso Sotsaka (210555976)
School of Education
Edgewood Campus

Dear Mr Sotsaka,

Protocol reference number: HSS/0952/015M
Project title: An exploration of the interface between Grade 11 Engineering Graphics and Design teachers' understanding of Assembly Drawing and their practice: A case study of the uThukela District, Kwa Zulu Natal

Full Approval – Expedited Application
In response to your application received on 17 July 2015. The Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol have 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

.....
Professor Urmilla Bob (University Dean of Research)
On behalf of Dr Shenuka Singh (Chair)

/ms

Cc Supervisor: Dr A Singh-Pillay and Mr MP Moodley
Cc Academic Leader Research: Professor P Morojele
Cc School Administrator: Ms Tyzer Khumalo / Ms Bongi Bhengu

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** xmbeap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

1910 - 2010
100 YEARS OF ACADEMIC EXCELLENCE
Founding Campuses: Edgewood, Howard College, Medical School, Pietermaritzburg, Westville

A2: EDITING CERTIFICATE

Sheelagh Halstead

BSc (Natal) HED (UNISA) MSc (UKZN)

Independent Education Consultant

66 Geekie Road

Merrivale

South Africa, 3291

tel: 0333304668

cell: 0823717650

email: halstead@nitrosoft.co.za

EDITING CERTIFICATE

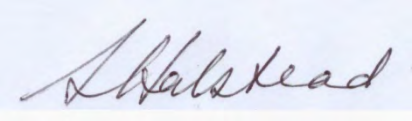
NAME: Douglas Thembinkosi Sibusiso Sotsaka

DISSERTATION TITLE: An exploration of the interface between Grade 11 Engineering Graphics and Design Teachers' understanding of Assembly Drawing and their practice: A case study of the uThukela District, KwaZulu-Natal

AFFILIATION: Science, Mathematics, and Technology Education Cluster, Faculty of Education, University of KwaZulu-Natal,

I confirm that I have edited this dissertation for grammar, appropriate use of academic language or conventions, and flow of the academic argument. I have also addressed formatting of the preliminary pages, the main text, figures, tables and references. I have recommended appropriate changes to the student and his supervisor.

I am a native English speaker. As an independent educational consultant, one of my specialisations is writing academic learning material and editing academic documents. I obtained a BSc at the University of Natal, with chemistry and applied mathematics majors. After graduation, I was a Research Officer in the Ministry of Roads and Road Traffic in, as was then, Rhodesia. My duties included writing reports and editing those by other authors. Some years later I entered the teaching profession and studied with UNISA for my postgraduate Higher Education Diploma, achieving a distinction for the English language module. After 20 years teaching at high school, I took up an academic position at the University of KwaZulu-Natal, where I completed an MSc in chemistry education and wrote several research articles. Since retirement three years ago, I have edited numerous academic papers and eight theses or dissertations, one of which was judged to be *cum laude*.



Sheelagh Edith Halstead, 18th December 2015

Appendix: B1

Edgewood Campus
Private Bag X03
Ashwood
3605

Dear: Head of Department: KZN DoE

RE: Request for permission to conduct research

My name is Douglas T.S. Sotsaka, I am a Masters candidate studying at the University of KwaZulu-Natal, Edgewood campus, South Africa. I am currently engaged in a research project entitled "An exploration of the interface between grade 11 Engineering Graphics and Design Teachers' understanding of Assembly Drawing and their practice: A case study of the uThukela District, KwaZulu-Natal". I hereby seek permission to conduct this project at the 11 schools offering EGD within the UThukela District. This study is purely for academic purposes and there will be no financial gain involved. It is expected that through this study that EGD teachers will teach AD in a more nuanced manner and this will improve learner performance in the AD question in the matric examination. You are assured that the findings of the research will not be used for any purpose other than the master's dissertation. In this regard, no harm will be caused to the KZN, DoE, and the educator/s participating in this study. Furthermore, teachers' anonymity is assured. Pseudonyms will be used to protect their identity as well as their schools identity. All information disclosed will be kept in confidence. The participation in this research is voluntary and should you find that you wish to withdraw or terminate your permission for the research, you may do so without any negative consequences.

Thank you.

Yours faithfully
Douglas T.S. Sotsaka

Should you have any queries you can contact my supervisors
Dr. A. Singh –Pillay
Telephone no: 031- 260 3672

Email: pillaya5@ukzn.ac.za

My Co-supervisor is Mr. M.P. Moodley
School of Education
Edgewood campus, University of KwaZulu-Natal
(Tel) 033-2605847 Email:moodleymp@ukzn.ac.za

The following personnel from the research office may be contacted:
Ms Phumelele Ximba Tel. No. 031 60 3587 Email: HssrecHumanities@ukzn.ac.za
Mr Premlall Mohun Tel. No. 031 260 4557 Email: HssrecHumanities@ukzn.ac.za

Appendix B2
Permission to conduct research

education

Department:
Education
PROVINCE OF KWAZULU-NATAL

Enquiries: Nomangisi Ngubane Tel: 033 392 1004 Ref.:2/4/8/404

Mr DTS Sotsaka
PO Box 2896
PIETERMARITZBURG
3200

Dear Mr Sotsaka

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: "**An exploration of the interface between grade 11 Engineering Graphics and Design Teachers' understanding of Assembly Drawing and their practice: A case study of the uThukela District, Kwa Zulu Natal"** in the KwaZulu-Natal Department of Education Institutions has been approved for following schools in the UThukela District:

Ladysmith High,
Klipriver Secondary
Tabhane Secondary
Tshanibezwe High,
Siphimfundo Secondary
Estcourt High,
Estcourt Secondary
Drakensburg Comprehensive High,
Enkomokazini Technical High,
Ntathakusa High and
Meadowsweet Combined School.

Kindly note, the conditions of the approval is as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.

5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from 15 May 2015 to 15 June 2016.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Miss Connie Kehologile at the contact numbers below.
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report / dissertation / thesis must be submitted to the research office of the Department. Please address it to The Office of the HOD, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education, UThukela District.

Wishing you well with your study.

_____

Nkosinathi S.P. Sishi, PhD
Head of Department: Ed
Date: 12 May 2015

KWAZULU-NATAL DEPARTMENT OF EDUCATION POSTAL: Private Bag X 9137, Pietermaritzburg, 3200, KwaZulu-Natal, Republic of South Africa PHYSICAL: 247 Burger Street, Anton Lembede House, Pietermaritzburg, 3201. Tel. 033 392 1004 EMAIL ADDRESS: kehologile.connie@kzndoe.gov.za / Nomangisi.Ngubane@kzndoe.gov.za CALL CENTRE: 0860 596 363; Fax: 033 392 1203 WEBSITE: WWW.kzneducation.gov.za

Appendix B3

School of Education,
College of Humanities,
University of KwaZulu-Natal,
Edgewood Campus,
16 July 2014

The Principal,

Sir/Madam

Permission to conduct research

My name is Douglas T.S. Sotsaka, I am a Masters candidate studying at the University of KwaZulu-Natal, Edgewood campus, South Africa. I am conducting research entitled:" An exploration of the interface between grade 11 Engineering Graphics and Design Teachers' understanding of Assembly Drawing and their practice: A case study of the uThukela District, Kwa Zulu Natal" .To gather the information, I will need access to grade 11 Engineering Graphics and Design to answer a questionnaire and participate in an individual interview. Permission will also be sought from the individual teacher.

Please note that:

- Your confidentiality is guaranteed as your inputs will not be attributed to you in person, but reported only as a population member opinion.
- You have a choice to participate, not participate or stop participating in the research. You will not be penalized for taking such an action.
- The research aims at understanding grade 11 EGD teachers perception of the AD and its impact on their teaching style.
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.
- If you are willing to grant me access to your school please indicate (by ticking as applicable)

	Granted	Not granted
Access		

I can be contacted at: Tel. No.: 033 845 9064

Cell. No.: 071 600 9826
e-mail : douglassibusiso@gmail.com

My supervisor is Dr. A. Singh- Pillay who is located at the School of Education, Science and Technology cluster, Edgewood campus of the University of KwaZulu-Natal.
Contact details: email: pillaya5@ukzn.ac.za Phone number: 031-26053672

My Co-supervisor is Mr. M.P. Moodley
School of Education Edgewood campus, University of KwaZulu-Natal
(Tel) 033-2605847 Email:moodleymp@ukzn.ac.za

The following personnel from the research office may be contacted:
Ms Phumelele Ximba Tel. No. 031 60 3587 Email: HssrecHumanities@ukzn.ac.za
Mr Premlall Mohun Tel. No. 031 260 4557 Email: HssrecHumanities@ukzn.ac.za

Thank you for your contribution to this research.

Declaration

I…… (full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project. I am also aware that I have the right to withdraw from the study at any time without any negative consequences.

_____ _____

Signature: Date

Appendix B4

School of Education,
College of Humanities,
University of KwaZulu-Natal,
Edgewood Campus,
16 April, 2015

Dear Participant

INFORMED CONSENT LETTER

My name is Douglas T.S. Sotsaka, I am a Masters candidate studying at the University of Zulu-Natal, Edgewood campus, South Africa. I am interested in learning about Grade 11 Engineering Graphics and Design teachers' understanding of AD and their practice of AD at selected high schools in Uthukela District. To gather the information, I will be asking you some questions via a questionnaire and an individual interview. I will also ask you to complete a task based on AD. I will also need to observe your lesson on AD. In addition I also require permission to video record the interview.
Please note that:

- Your confidentiality is guaranteed as your inputs will not be attributed to you in person, but reported only as a population member opinion.
- The task based activity will take 30 minutes
- The questionnaire will take 10 minutes to answer and interview may last for about 20 minutes and may be split depending on your preference.
- Any information given by you cannot be used against you, and the collected data will be used for purposes of this research only.
- Data will be stored in secure storage and destroyed after 5 years.
- You have a choice to participate, not participate or stop participating in the research. You will not be penalized for taking such an action.
- The research aims at understanding Grade 11 Engineering Graphics and Design teachers' understanding of AD and practice of AD at selected high schools in Uthukela District.
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.
- If you are willing to be interviewed and have the interview video recorded please indicate (by ticking as applicable) whether or not you are willing to allow the recording by the following equipment:

	willing	Not willing
Audio equipment		
Video equipment		
Lesson observation		

I can be contacted at: Tel. No.: 033 845 9064
Cell. No.: 071 600 9826
e-mail : douglassibusiso@gmail.com

My supervisor is Dr. A. Singh- Pillay who is located at the School of Education, Science and Technology cluster, Edgewood campus of the University of KwaZulu-Natal.
Contact details: email: pillaya5@ukzn.ac.za Phone number: 031-26053672

My Co-supervisor is Mr. MP Moodley
School of Education
Edgewood campus, University of KwaZulu-Natal
(Tel): 033-2605847 Email: moodleymp@ukzn.ac.za

The following personnel from the research office may be contacted:
Ms Phumelele Ximba Tel. No. 031 60 3587 Email: HssrecHumanities@ukzn.ac.za
Mr Premlall Mohun Tel. No. 031 260 4557 Email: HssrecHumanities@ukzn.ac.za

Thank you for your contribution to this research.

DECLARATION

I…… (full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

_____ _____

Signature Date

Appendix C1

Questionnaire

A. Please complete the information needed below:

Age	
Gender	
Number of years teaching in general	
Number of years teaching Engineering Graphics and Design	
Qualification/s	
Qualification in Engineering Graphics and Design (Please specify)	
Have you attended any training in Engineering Graphics and Design for teaching and assessing AD? Please elaborate about the training and its duration	
How many periods of in Engineering Graphics and Design do you teach per week?	
How many periods of in Engineering Graphics and Design make up your workload?	
Do you teach other learning areas? - Please list them	
Please indicate the number of	

period's these other learning areas contribute to your workload.	
Level on which you are employed e.g. L1 , L2	Level:
Nature of appointment: Permanent/ temporary	

1. What is your understanding of Assembly drawing? please explain
   _____
   _____

2. What are your views on teaching and assessing assembly drawing? Please elaborate

_____
_____
_____
_____
_____
_____

3. Do you enjoy teaching and assessing learners in this section? Please explain.

_____
_____
_____
_____
_____

4. How would you describe your practice of AD?

_____
_____
_____
_____

5. What type/types of classwork do you engage learners in or prefer to engage learner in when it comes to AD? Please elaborate\

_____
_____
_____
_____
_____
_____

6. Do you have the resources to engage in classwork as required by the CAPS document for AD? Please explain.

7. Do you feel adequately trained to implement the demands made on you in respect of the teaching and assessing in this section of work? Please elaborate.

8. What are your views on the content knowledge and skills that the grade 10 and 11 EGD learners are expected to have/ to know pertaining to AD? Please explain.

9. What strategies /method you do use to improvise for resources that are lacking at your school for the teaching and assessing of assembly drawing? Please explain.

10. Do you consult with students for resources? Please explain

11. What support structures are available to you for the teaching and assessing assembly drawing? Kindly explain.

Appendix C2

Observation schedule

OBSREVATION SCHEDULE
Date:

1. Physical setting.
Time:
The physical setting involves the physical environment (including resources) and its organization.

School name:
Location:

Rural	Semi- rural	urban	Semi-urban

School Type:

Quintile ranking	GET	FET	BOTH GET &FET

Facility	**Availability**	**comment**
Classroom facility		
Grade 11 classroom permanent		
Grade 11 classroom temporary		
Desk per classroom		
Writing board		
Dedicated display area for charts		
Teachers' table		
Teachers' table		
cupboard		
textbooks		
stationary		
Writing aid		
Drawing tables		
stools		
Administrative facilities		
Principal's office		
Secretary office		
Stock room		
HoD office		
staffroom		
Educational facilities		
Library		
Library books		
EGD room		
Computers room		
computers		
Data projector		

White board		
Overhead projector		
Photocopy machine		
posters		
Internet		
Recreational facilities		
Sports field		
Sports equipment		
gym		
Infrastructure facilities		
toilets		
water		
fence		
Security system		
Access by road		

2. Human setting

The human setting involves the organization of people, the characteristics and make- up of the groups or individuals being observed.

Learner information

Grade	Number of learners doing EGD	No. boys	No. girls
12			
11			
10			

How do learners get to school?

Walk	Bus	taxi	bicycle	Parents transport

Staff information

Principal	**Deputy principal**	**Head of departments**	**Teachers**	**SGB Teachers**	**cleaners**	**Security guards**

School's language policy _

Language used	**English**	**isiZulu**	**Afrikaans**	**other**
Learners home				

language				
EGD Teachers home language				
Language used in EDG classroom during teaching and learning				
Language used during group discussion				

3. Programme setting

Programme setting involves pedagogic styles, curricula and their organization.

What kind of curriculum is being followed and how does it caters for teaching and learning in context?

What characterizes the pedagogic style of the EGD Teacher? How does the style cater for teaching and learning in this context?

How does the teacher engage his or her learners in the teaching and learning situation?

How are learners engaged in AD?

How are learners being assessed in AD?

Interactional setting

The interactional setting involves formal, informal, planned, unplanned and verbal, non-verbal interactions that take place during observation.

Theme	Guiding questions	comment
Structural	How is the lesson introduced?	
	What is the pace of the lesson?	
	What were the specific aims for learners to learn in this lesson?	
	What motivation was given for learners to learn /follow the intended outcomes?	
	How is the lesson concluded?	
	What type/kind of activity did learners engage in?	
Methods	What approaches are used to organize and stimulate learner learning or cater for learner misconceptions?	
	Teaching procedure and reasons for using these procedures to engage with teaching of AD	
	What teaching and learning resources are used in the lesson?	
	How do learners respond to the methods?	
	Were Difficulties /limitations connected with teaching this idea noted/justified/explained	
	Was there a link between knowledge about learners thinking that influences the teaching of the AD	
	What other factors influenced the teaching of this idea/AD?	
Overall impression	What is the atmosphere in the lesson like?	
	How did the teacher relate to the learners?	
	How are learners with special needs catered for?	

Interaction	comment
Formal	
Informal	
Planned	
unplanned	
verbal	
Non –verbal	

Appendix C3

Pre-observation interview;

1. What will you be teaching?
2. What teaching strategy are you going to use to teach this section?
3. How are you going to use this strategy to teach this section? please describe what you will be doing
4. Please explain why you have selected to use this particular strategy to teach this aspect?

Appendix C4

Post observation interview:

1. Please explain why you chose the methods you did when teaching AD?

2. In your view does this method used promote learning/address learners misconceptions?

3. When learners battle to understand and cannot draw how you support them?

4. What contextual factors promote your teaching of AD?

5. What contextual factors inhibit your teaching of AD?

6. Do you enjoy teaching AD?

7. If you were in an idea context how would your teaching of AD differ from the lesson I observed.

8. What do you do to enable learning understanding of and engagement with AD?

Appendix D1: Questionnaire responses:

RQ1: Teachers understanding of AD

RQ1	T1	2	3	4	5	6	7	8	9	10	11	12	13
Understanding of AD	Putting parts together	Putting parts together to make structures and draw	Putting things +drawing	Putting parts together	Putting parts together	Putting parts together to make structure and draw	assembling or sectioning of mechanical components, visualizing 3D parts from 2D drawings, visually manipulating applying sans code	Putting things to see how they function	Putting parts together	Putting thing together	Putting parts together	Putting thing together	putting together mechanical component only, seeing that they function
Skills needed	physical	drawing	Mechanical	physical	mechanical	drawing	Visual reasoning, special perception	manipulation	Physical	Physical	Physical	manipulation	Manipulation critical thinking

RQ1: Teachers' practice of AD

RQ2	T1	2	3	4	5	6	7	8	9	10	11	12	13
Practice of AD	Chalk n talk	Chalk n talk	Chalk n talk	Chalk n talk	Chalk n talk	Chalk n talk	Demonstrations, hands on activities, projects	Lecture method + demo's	Chalk n talk	Chalk n talk	Chalk n talk	Chalk n talk	Lecture methods n demo's

Appendix D2: Focus group interview responses:

I: What is your understanding of AD?

T1*:* It is just the putting together of components- you must not complicate this or you have to find a way to teach it- this is not a section I like,

T6: I agree with him

T5: Me too. I don't like teaching this section, I don't understand it, learners perform poorly, for me is putting parts together- I'm surviving with this"

T2: what about drawing, AD is putting things together to make a structure and you have to draw it

I: Yes you, over there

T13: It's putting together mechanical component only, seeing that they function and then drawing it----this is like you are testing us or something

I : it's not a test , I just asking what you understand by AD , that all , ok mam , you tell me your understanding of AD

T7: It is not as easy or straightforward as they are making it, it's a complex process, it does involve assembling or sectioning of mechanical components, visualizing 3D parts from 2D drawings, visually manipulating them as per specification and construction the diagram, you must also know your lines and codes

I, OK , see I'm not agreeing or disagreeing with you , so this is not a test, please tell me about how you teach AD, or what works for you when teaching AD

T9: We need auto cad to help, but we don't have it at my school so I do what I think is right, the training we receive is poor, it don't show us how to teach AD, in this training we need hands on training not a theory lesson on what should be done, I draw and learner copy or they trace from my drawings on worksheets

T4: There are no models, so I have to draw on the board and learners copy how to put components together and practice drawing, this is not the only subject I'm teaching two other

subjects, I'm trying to survive here, the training we get to implement this CAPS is so poor, the trainer needs training, I have no time to go and get models from scrap yards, they just follow, there is no thinking here only coping drawings, hey they don't keep quite when I'm busy drawing, these learners are so rude

T13: the lecture method coupled with demonstration work well, resources are hard to come by here – as I explain what is expected off the learner in the exams and then demonstrate what must be done and explain why it must be done.

T8: I use teacher demonstration due to time constrains and there being not enough models to let student engage in hands on activities, but in this way learners can see how to put these machine parts and understand how they work, then they draw, I try my best, with all the challenges we encounter in our schools, discipline issues, poor attendance

I: you sir, how do you teach AD

T3: Chalk and talk, but more chalk and less talk

I why?

T3: No resources

T4: Me as well, I also do that chalk and talk as I have no resources

I: mam you, what do you do

T7: I use demonstrations; hands on projects Learners have great difficulty in visualizing objects in 3D. in the absence of this skill it is hard to draw different views of an object. Learners are expected to do this in the exams, Therefore I demonstrate these views by sectioning models, get learner to assemble parts in group, then draw the various views, I also give them the past year exams questions , so they know what is required in AD, they must be able to get all the taken for granted marks in the section, I provide detailed feedback on their drawings so they know what they did wrong.

I: Thank you, everybody

Appendix D3: Teacher -7: post observation interview

I: Now I am going to ask you questions based on the lesson that you have just taught, my first question is, can you please explain to me why you chose the method you used in teaching assemble drawing?

T7: I chose that method because they get to be hands on when they assemble the parts, and they get to learn how those parts are connected

I: In your own opinion do you think this type of method you used promotes learning and addresses learner's misconception or their misunderstanding

T7: Yes because and especially that particular case as you noticed when I gave them that particular workshop, there was that schematic diagram where they were just guided on how to put the parts together but when they trace the parts and put them together, that addresses them all on their misconceptions and on problems that are normal when you teach on this particular problem or this particular topic.

I: When learners battle to understand and cannot draw, how do you support them, when they experience such difficulties?

T7: well in that particular case remember there are methods in place that you use as a teacher and you find that learners are not the same so you have to cater to their individual needs, those that don't understand when I teach, I take them back where I use computer examples, I have got models that I use where they take parts apart and then put them back together so that they can see that assemble drawing is not something that is very abstract but it is something that they do every day, where they just put the parts together.

I: what conceptual factors promotes your teaching of this topic, assemble drawing, the environment and resources?

T7: I must say uhhhmm… I am very fortunate that when I teach this particular section, I give my learners an opportunity to go to the nearest scrapyard, there are lots of them, there's one here near the school (*pointing towards the direction of its location*), so they go there and ask for any machine part, and they would cut it then draw it so that they can see that *uhmmm*… assemble drawing is something that is very interesting and that it is not only for mechanical engineers only, but it's also for us because we do it on daily basis, I also have models that I have developed by doing so and I always say uhmmm other than the transparencies and the tracing papers that can be used also have a lot of models that my learners developed from going to the nearest scrapyard and getting all those things.

I: And what conceptual factors inhibit your teaching of assemble drawing, do you have any conceptual factors?

T7: uhhm… not really, I would say I would like to teach using Auto CAD (Computer Added Drawing) and we are working on that, my biggest challenge is that uhmmm… we don't have enough computers at the moment for the EGD learners but we are working on that though they

will be getting laptops, and so I have only managed to download Auto CAD for them because I have found that it is so much easier the Auto CAD program.

I: so do you enjoy teaching assembly drawing?

T7: Of course yes and from my experience my learners do well in that particular section because it's the one I love most because I make sure that I make time when teaching it, however there are times where there are challenges where you find that they are slow and they do not complete the drawing fast enough but even though it's not that they don't know what to do, I make sure that I teach them thoroughly and I enjoy it.

I: if you were in an ideal context, how would you teach your teaching of assembly drawing differ from the one I have just been observing now, so like if you were in a very good school what would you do?

T7: I think that question is so simple because the only challenge I have at the moment is the program (CAD software), the resources, you know like the projector and the computers. So if I can get the Auto CAD program (software), that will firstly help me with time consumption spent on the lesson, remember we are using the tracing paper and by using the computer it would be much easier because it's a process of just cut and paste and it also minimizes time, so for me that would be more convenient when using the computer software called the Auto CAD, because it think it would be more enjoyable in learning it, for one simple reason that you will not need to redraw the components,, you will just cut and paste and we would be able to use colours so that the learners can see easily and clearly, so I was going to use that.

I: okay so tell me what do you do to enable your learning and teaching in order for learners to be effective in this section of assemble drawing, what is your secret?

(Smiles)…

T7: I can say that, I will be honest with you, what has helped me a lot is uhmmm marking, and monitoring the CASS files of other teachers in our region when I started marking I was marking this section…

I: what do you mean marking?

T7: I mean marking the papers for grade 12's yes…

I: so it was that exposure that…

T7: …that exposure yes…because like I was looking at what other candidates were doing differently there and exam comments they had, the different errors that the candidates made and then I brought that experience back to my learners and made sure that I did workshops for my learners based on some of the little mistakes commonly made, so that my learners know exactly what to do when it comes to those sections, but all in all it's because of the experience I get from

the outside when doing the marking of papers and also networking, I do communicate with a lot of teachers not only in my area in Durban, as well I make sure that I get some ideas from other teachers because when you are a human being it is not like you know everything, so I learn from other people.

I: Okay, thank you so much for this information

T7: you are welcome (smiles)…

D4: Teacher -8: post observation interview

I: Good afternoon sir

T8: hello

I: How are you?

T8: I'm fine Thanks

I: Alright so after observing your lesson I am going to ask you a few questions based on the topic you were teaching about, that is AD (Assemble Drawing), so my first question is can you please explain why you choose the method of teaching you used in teaching the Assemble drawing?

T8: First of all I think using this type of technique was for me the first time doing it and or the type of chapter we are using it

I: So you are saying you use a (unclear) and so you feel it the best time to introduce it for the first time as assemble drawings?

T8: Nods,

I: Okay now in your own view do you think the method of teaching you use promotes or addresses learners' misconception or misunderstanding of this section Assembly Drawing?

T8: in my own view?

I: yes

T8: can you please repeat the question

I: Okay yes, in your own view does this type of method you use promote or address the learners' misconception or misunderstanding on assembly drawing?

T8: I think it does promote the learning successfully, and because some like "AD" assembly drawing the machines they used to see in their own lives, like bends when I was introducing the bicycle they used to ride it… yah…

I: Right, so you think that it was the suitable one to use in order to get them to understand the lesson?

T8: Yes…

I: Okay, when learner battle or struggle to understand assembly drawing, how do you support them?

T8: This year is a “lucky year”, because I have a small group of learners so it’s easier for me to go around checking up on their work while they attend to the task given to them, and together discuss the difficulties they face…

I: Even with the individual time sheet, just to assist them with answering the questions and understanding…

T8: (agrees along with the field worker…)

I: now tell me, what contextual factors promote your teaching of Assembly Drawing?

T8: Let me just say that, externally , I mark matric paper, but internally there are no contextual factors yet, because in this school we lack basic resources…

I: (joins in…) …to motivate you and enable you to teach this section…but you have a few models, I saw them

T8: Nods

I: So now what conceptual factors inhibit you in teaching your lesson? So like what challenges or hurdles that you are facing when you are addressing or when you are conducting a lesson based on Assembly Drawing?

T8: Okay the contextual factors are first thing I'm facing is that there is no drawing classroom, even the desks they use for drawing lessons, are not suitable for this lesson, secondly there is no basic instruments to be used for the kids to learn with easily, if there is one they would be not enough for the class, they borrow from each other or share amongst each other, and just basic resources to make the work easier. Conceptually I cope with AD

I: Okay now tell me, do you really enjoy teaching assembly drawing?

T8: (smirks)… yeas I do it’s just that it’s very discouraging not to have resources to make our job easier for the kids to learn. But in fact I do.

I: So now because of the resources, but you do have I saw them …

T8: (joins in) …yah but I want more, …

I: now tell me, if you were in an ideal context, how would your teaching of assembly drawing be different from the lesson I have observed?

T8: Les just say in this school they have more models, so that before they write or draw they would see the type of models we are talking about, so that it would be easy for the learners to draw because they would have the image of the model in their minds, but I don't at the moment (have enough models to show to the kids as an illustration for them) the only have the ones illustrated only on paper and only write based on that.

I: Okay, now, what do you do to enable learning and understanding of individual with this AD (assembly drawing), so what do you do to make sure that your learners understand this section?

T8: At the moment I do tests and at the moment the school does not have the resources and the models, but what I do is before I attend to my class I prepare for my class by re-drawing thoroughly the sketch and then give them examples of what they are used to seeing around them, like (unclear)…

T8: (STUTTERING) I give them more work to do at home because in school we have less time to do more like we have an hour per lesson which is not enough to add more activities for the learners

I: Thank you very much for answering my question

Appendix: D5: Observation of lesson

Observation schedule: School A

1. Physical setting.
Time:
The physical setting involves the physical environment (including resources) and its organization.

School name: A
Location:

Rural	Semi- rural	urban	Semi-urban
	x		

School Type:

Quintile ranking	GET	FET	BOTH GET &FET
1			x

Facility	**Availability**	**comment**
Classroom facility		
Grade 11 classroom permanent		
Grade 11 classroom temporary		
Desk per classroom		Few- learners share
Writing board		x
Dedicated display area for charts		no
Teachers' table		no
Teachers' table		no
cupboard		no
textbooks		Yes- few –learners share
stationary		yes
Writing aid		-
Drawing tables		no
stools		no
Administrative facilities		
Principal's office		yes
Secretary office		yes
Stock room		yes
HoD office		yes
staffroom		yes
Educational facilities		
Library		Yes-
Library books		few
EGD room		no
Computers room		no

computers		In principals office only
Data projector		no
White board		no
Overhead projector		no
Photocopy machine		yes
posters		Hand drawn
Internet		no
Recreational facilities		
Sports field		yes
Sports equipment		Soccer
gym		no
Infrastructure facilities		
toilets		yes
water		yes
fence		yes
Security system		no
Access by road		yes

Principal	Deputy principal	Head of departments	Teachers	SGB Teachers	cleaners	Security guards
1	**2**	**3**	**23**	**no**	**1**	**no**

School's language policy _

English officially – but isiZulu used to teach as well

Language used	English	isiZulu	Afrikaans	other
Learners home language		x		
EGD Teachers home language		x		
Language used in EDG classroom during teaching and learning	x	x		
Language used during group discussion		x		

3. Programme setting

The NCS-CAPS curriculum is the official policy being followed at this school. This curriculum embraces a learner centered approach to teaching and learning. During the pre-observation interview the teacher had indicated that he was going to teach orthographic projects by first and third angle methods using a chart and a model to demonstrate and learner will be involved in hands on activities. During the lesson the teacher used a teacher dominated approach to teaching. There is very little room for learner engagement with the "content", there is little or no opportunities for learners to engage with what is drawn on the board. Learners have to copy what's on the board and their drawings are assessed according to the degree of replication to the drawing on the board. Co-incidentally the NSC EGD pass rate at this school is below 50%. An examination of the teacher's master portfolio shows that this particular EGD teacher does not use the EGD – CAPS curriculum to plan his teaching and learning, so there is limited transfer of curriculum content to context. The aims of the lessons are not aligned to the goals of the curriculum- the teacher does not foreground orthographic projection, sectioning, use of drafting conventions, dimensioning, pictorial views and sketching in his lessons. The pace of the lesson and learning is hindered by the teachers' practice of drawing on the chalkboard. An examination of the learners CASS portfolio reveals that no feedback is provided to learners on their replicas of the teachers drawings nether are learners provided with a rubric to guide them during their assessment. The atmosphere in the classroom was rigid with no room for learner engagement or creativity. After my observation of the lesson I asked the teacher if he was going to be available for the post observation interview he stated he had changed his mind as he does not want an inquiry into his teaching

Observation schedule: School B

School name: B

Location:

Rural	Semi- rural	urban	Semi-urban

School Type:

Quintile ranking	GET	FET	BOTH GET &FET
2			x

Facility	**Availability**	**comment**
Classroom facility		
Grade 11 classroom permanent		X
Grade 11 classroom temporary		No
Desk per classroom		Yes- but shortages
Writing board		x
Dedicated display area for charts		yes
Teachers' table		yes
Teachers' table		yes
cupboard		yes
textbooks		Yes- few –learners share
stationary		yes
Writing aid		-
Drawing tables		few

stools		few
Administrative facilities		
Principal's office		yes
Secretary office		yes
Stock room		yes
HoD office		yes
staffroom		yes
Educational facilities		
Library		Yes-
Library books		-
EGD room		yes
Computers room		no
computers		In principals office and admin
Data projector		no
White board		no
Overhead projector		yes
Photocopy machine		yes
posters		Hand drawn
Internet		no
Recreational facilities		
Sports field		yes
Sports equipment		Soccer
gym		no
Infrastructure facilities		
toilets		yes
water		yes
fence		yes
Security system		yes
Access by road		yes

Principal	**Deputy principal**	**Head of departments**	**Teachers**	**SGB Teachers**	**cleaners**	**Security guards**
1	**1**	**4**	**20**	**no**	**4**	**1**

School's language policy _

English officially – but isiZulu used to teach as well

Language used	**English**	**isiZulu**	**Afrikaans**	**other**
Learners home language		x		
EGD Teachers		x		

home language				
Language used in EDG classroom during teaching and learning	x	x		
Language used during group discussion		x		

3. Programme setting

The NCS-CAPS curriculum is the official policy being followed at this school. This curriculum embraces a learner centered approach to teaching and learning. During the pre-observation interview the teacher had indicated that he was going to teach via demonstrations and a lecture method the use of elementary standard practice, conventions, abbreviations and machine symbols, the use of part sections to show machine details. Co-incidentally the NSC EGD pass rate at this school is above 60%. An examination of the teacher's master portfolio shows that this particular EGD teacher uses the EGD – CAPS curriculum to plan his teaching and learning, so there is transfer of curriculum content to context. The aims of the lessons are aligned to the goals of the curriculum- the teacher has foreground orthographic projection, sectioning, use of drafting conventions, dimensioning, pictorial views and sketching in his lessons. The pace of the lesson and learning is aligned to the KZN DBE work scheduled provided to teachers. An examination of the learners CASS portfolio reveals that they are provided with multiple opportunities to engage with NSC exam type questions. The atmosphere in the classroom was relaxed and learners ask questions

Observation schedule: School C

School name: C

Location:

Rural	Semi- rural	urban	Semi-urban
		x	

School Type:

Quintile ranking	GET	FET	BOTH GET &FET
4			x

Facility	**Availability**	**comment**
Classroom facility		
Grade 11 classroom permanent		X
Grade 11 classroom temporary		No
Desk per classroom		Yes-
Writing board		x
Dedicated display area for charts		yes

Teachers' table		yes
Teachers' table		yes
cupboard		yes
textbooks		Yes-
stationary		yes
Writing aid		-
Drawing tables		few
stools		few
Administrative facilities		
Principal's office		yes
Secretary office		yes
Stock room		yes
HoD office		yes
staffroom		yes
Educational facilities		
Library		Yes-
Library books		-yes
EGD room		yes
Computers room		yes
computers		yes
Data projector		yes
White board		yes
Overhead projector		yes
Photocopy machine		yes
posters		Yes
Internet		YES
Recreational facilities		
Sports field		yes
Sports equipment		Soccer
gym		YES
Infrastructure facilities		
toilets		yes
water		yes
fence		yes
Security system		yes
Access by road		yes

Principal	**Deputy principal**	**Head of departments**	**Teachers**	**SGB Teachers**	**cleaners**	**Security guards**
1	**2**	**4**	**20**	**10**	**8**	**2**

School's language policy _

English officially –

Language used	English	isiZulu	Afrikaans	other
Learners home language		x		
EGD Teachers home language		x		
Language used in EDG classroom during teaching and learning	x			
Language used during group discussion	X			

3. Programme setting

The NCS-CAPS curriculum is the official policy being followed at this school. This curriculum embraces a learner centered approach to teaching and learning. During the pre-observation interview the teacher had indicated that she was going to teach via demonstrations and a mini hands on project the drawing of pictorial views of a machine in accordance with SANS. The NSC EGD pass rate at this school is above 78%. An examination of the teacher's master portfolio shows that this particular EGD teacher teaching and learning outcomes are aligned with that of the CAPS –EGD curriculum. There is maximum transfer of curriculum content to context. The aims of the lessons are aligned to the goals of the curriculum- the teacher has foreground orthographic projection, sectioning, use of drafting conventions, dimensioning, pictorial views and sketching in her lessons. There is ample evidence of rigour in the assessment tasks given to learner. Learners are provided with many chances to master the skills required to excel in AD and the assessment tasks consist of higher order questions as well. The pace of the lesson and learning is aligned to the KZN DBE work scheduled provided to teachers. An examination of the learners CASS portfolio reveals that they are provided with details feedback on all their assessment tasks to help them identify their areas of weakness and scaffold their learning. The atmosphere in the classroom was relaxed and learners worked in group and asked for feedback on their projects freely. The teacher actively encourages learner to ask questions while their engage in hands on activities. This EGD teacher facilitates learning.

During the post observation interview this EGD teacher highlight justified her preferred method of teaching AD: hands on project work as it allows for learning by doing, stimulates curiosity,

and learner creativity. This method works as the learners pass rate and quality of passes in the NSC EGD exams is improving each year. The aim to is obtain a 100 % pass rate with high quality passes