Classroom discourse to enhance the understanding of analytical drawings in engineering graphics and design

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ABSTRACT: The purpose of this study was to explore how engineering graphics and design (EGD) teachers used classroom discourse to enhance the students' understanding of analytical drawings. This study was guided by Bybee's 5E instructional model. Through a descriptive quantitative research design, the researcher examined three teachers and 170 students who were dealing with analytical drawings in preparation for a national examination. The findings indicate that often EGD teachers do not have a lesson presentation sequence, which makes it difficult for them to use techniques that may benefit their students in terms of reasoning and interpretation skills. As a recommendation, an EGD lesson presentation framework was presented to guide teachers on how they may use different teaching techniques, such as classroom discourse, thereby improving the students' learning outcomes.

INTRODUCTION

There have been several theoretical accounts that commend the use of classroom discourse technique to foster conducive instructional experience. Classroom discourse is traditionally known as a language of interaction between teachers and students [1]. Most recently, its momentum in the education space has drastically improved due to its prominence in eliciting knowledge. To date, it is used as a tool to encourage critical thinking, reasoning, making arguments, reflecting, representing and increasing concept understanding in classroom [2]. It has been widely used within abstract and practical subjects to expand knowledge and understanding. However, little is known on its use in regard to spatial visualisation skills. Thus, this study sought to explore how engineering graphics and design (EGD) teachers use classroom discourse during analytical drawing lessons.

Analytical drawings are supposed to equip students with visual qualities, such as line interpretations, drawing descriptions, dimensioning, symbols, calculations and drawing context orientations. For example, if students are given a site plan activity, they may be required to identify, analyse, interpret or calculate elements of that cite plan drawing to subsequently acquire designing, reorganising or interpreting skills which are linked to classroom discourse [3-5]. In fact, classroom discourse presents a chance for students to collectively share ideas, debate and take informed decisions based on those interactions with their teachers and fellow students. By implication, this is equally essential for the presentation of analytical drawing lessons since the content structure provides more interaction opportunities than other EGD units. Thus, this study sought to contribute to existing literature in this regard.

Notwithstanding the educational achievements in engineering graphics and design reported in the relevant literature thus far, this study argues that there has been no attention given to suitable instructional practices to learn analytical drawings. More specifically, the current research interest is in effective teaching-learning methods for first-year engineering graphics and design students [6], identifying gaps in the pedagogical content knowledge of fourth-year degree pre-service teachers in teaching engineering graphics and design [7], and considering Webster's learning-centred paradigm for engineering graphics and design [8]. Even though these studies addressed classroom-based challenges in EGD, they had a linear focus, and did not suggest instructional strategies necessary for learning drawings. In view of these limitations, this study argues that the previous research has not gone far enough in regard to the use of classroom discourse in EGD analytical drawing, and it aims to address this gap.

ENGINEERING GRAPHICS AND DESIGN IN SOUTH AFRICAN SCHOOLS

For a long period of time, engineering graphics and design has been taught in a selected number of schools in South Africa. However, since the government accentuated the need to have more students with technical and vocational abilities in order to increase a skilled society, most schools began to enrol students for this subject [9]. Mining and

petroleum industries were among those who heeded to the call by assisting in building technical schools that focus on equipping students with EGD skills. Also, through their schools' projects, bursary schemes and scholarships, these industries have managed to attract a reasonable number of students to enrol for this subject [10]. However, this increased enrolment was met with some difficulties, including the of lack of resources and appropriately qualified teaching personnel, consequently forcing teacher training institutions to increase their intake of prospective EGD teachers in order to bridge the gap.

To date, the number of qualified EGD teachers has significantly improved. However, most of these teachers have only learned EGD at tertiary institutions and do not have practical experience in how it should be taught in schools. Hence, how can they use classroom discourse when they have not been exposed to it during their teacher training stage? This issue is raised by Skosana who points out that most students acquire their EGD teaching qualification without sufficient guidance from mentor teachers during work-based learning programmes [6]. Other research also echoes this assertion that although student teachers acquire teaching experience through the work-based learning programmes, these programmes last only for a few weeks, which is not sufficient to equip them with content presentation and didactic skills [9][11]. Subsequently, this study is based on the hypothesis that most teachers cannot successfully interact with students, so that drawings are well understood, and that they are not proficient in using the classroom discourse technique.

USING CLASSROOM DISCOURSE IN EGD CLASSROOM

Usually, teachers strive to complete the curriculum rather than to impart core, transversal and general competencies [12]. These competencies are the ones to provide alternative starting points for learning design [13]. Students' poor performance has always been associated with poor lesson delivery and students' lack of commitment to their own learning [14]. As such, classroom discourse is commended to bridge the gap of poor lesson delivery and increase students' commitment to their learning.

The diagnostic reports by the Department of Basic Education (DBE) in South Africa, in the past three years of EGD examinations, reveal that students performed poorly in analytical drawing concepts, specifically in knowledge, calculations and symbols [15]. These include drawing third or first angle orthographic symbols, calculations of area, volumes and perimeters. This may indicate that if students find analytical drawing challenging, it is possible that teachers do not sufficiently engage students, in, for example, classroom discourses so that they understand, apply, and are able to analyse the learned concepts.

Engineering graphics and design is concerned with drawing and is complementary to the civil, electrical and mechanical technology content. Students should have sound knowledge of what they are drawing [16]. Regrettably, most teachers tend to isolate this subject from its corresponding subjects resulting in the lack of context and educational engagement. In some instances, schools would only offer EGD without its complementary subjects subsequently rendering it inferior [17].

Despite that this may be an external factor, it has the potential to contribute to the teachers' neglect of the importance of context teaching. Perhaps, poor performance in this subject results from the lack of suitable teaching techniques. Thus, this study proposes the use of classroom discourse in analytical drawings as contextual information is critical in this case. This approach is supported by Peterson et al who opine that classroom discourse assists teachers to quickly identify misconceptions that may occur in the understanding of concepts, and help students overcome any difficulties they have in learning concepts [18].

STUDY PURPOSE

The purpose of this study was to explore how engineering graphics and design teachers use classroom discourse to enhance the understanding of analytical drawing concepts. Hence, the following question was posed:

How do engineering graphics and design teachers use classroom discourse to enhance the understanding of analytical drawing?

METHODOLOGY

A descriptive quantitative research design was employed in this study, with a qualitative component to obtain more insight into the EGD classroom activities. According to Stake [19] and Creswell [20], a quantitative research design is a method that is used by researchers to study quantified relationships between variables. So, this method was deemed appropriate, because the researcher did not control the variables which opened room for unrestricted and natural emergence of themes identified in the study [21]. In addition, this method enabled the compilation of occurrences of classroom discourse involved in the EGD classroom's analytical drawings.

Sampling

Non-probability sampling was employed, which comprised of three EGD teachers from different districts of Limpopo province in South Africa, and a total of one-hundred and seventy (170) EGD students. All respondents who agreed to

participate were assured they would remain anonymous. Ethical clearance was granted by the Ethics Committee of the University at which the researcher is affiliated.

Data Collection Instruments

As the data collection instrument, this study used questionnaires along with non-participant observation. It was noted as important that the instrument does not control how events should take place, but allows to understand how they actually take place and that the collected data leads to greater trustworthiness of the instrument. The participants were given back their inputs to verify that they were a true reflection of the data input. This was done to ensure validity of the research study [21].

Data Analysis

Questionnaires were analysed by means of Statistical Package for the Social Sciences (SPSS). Participant inputs were converted to percentages for both closed- and open-ended inputs using a three-point Linkert scale. Observations were analysed thematically as provisioned by Bybee's 5E instructional model. An open circle bullet was used to indicate where the observation input was relevant on the observation checklist. Creswell points out that …*confirmability involves neutrality of the research interpretations, which can be enhanced by triangulation* [20]. Therefore, in this study, the interpretations were checked by a critical fellow who checked for compliance and representation to confirm them as a true reflection. The elements of observation were guided by Bybee's 5E instructional model phases to ensure dependability of the data [22].

5 E-INSTRUCTIONAL MODEL

This study was guided by Bybee's 5E instructional model [22]. The 5E instruction is a way of processing information and learning by creating opportunities for active learning, learning how to ask questions, draw conclusions, make arguments, and work collaboratively with peers to construct meanings and carry out investigation [22]. The use of this model was strengthened by Eisenkraft's assertion that the E instructional model can be used to explore how knowledge is built in classroom practice [23]. Thus, this qualifies its relevance to this current study as it merges the traits of classroom discourse.

In order to implement a carefully planned sequence of instruction that is student-centred, Bybee proposes the following phases of instruction; namely, engage, explore, explain, elaborate and evaluate [22]. Accordingly, *engage* involve the connections between past and present learning experiences. Exposing students to prior knowledge is essential to organise thinking in the learning sequence. *Explore* deals with a build-up from prior knowledge, once students have engaged in activities, they need time to explore ideas. Exploration activities are designed, so that students share experiences, which can be used later when formally introducing and discussing technological concepts.

Explain involves teachers asking questions and further providing resources and information to support student learning and it introduces technological concepts. The *elaborate* phase provides time for students to apply their understanding of concepts and skills. They might apply their understanding to similar phenomena or problems. Lastly, the *evaluate* phase encourages students to assess their understanding and abilities, and consents teachers to evaluate individual students' progress toward achieving learning goals and outcomes.

RESULTS

In order to achieve the purpose of this study, the figure below (Figure 1) was extracted from the Department of Basic Education 2018 examination paper, which was used for observation. However, apart from Figure 1, the teachers were firstly asked some questions in order to understand their lesson presentation difficulties, which would then be used to expand the understanding of the observation data.

The three teachers' responses regarding teaching competencies are included in Table 1, while Table 2 includes the findings from the three schools on the teachers' instructional practices using Bybee's 5E instructional model themes. The three EGD teachers were involved in a special programme of assisting Grade 12 EGD students in preparation for their final examinations.

Table 1: EGD teachers' responses regarding teaching competencies.

Concerns	Agree	Sometimes	Disagree
Do you have difficulties in teaching any of the EGD units?	-	-	100% (3)
Do you have a specific teaching pattern for EGD?	33.33% (1)	-	66.66% (2)
Can EGD be taught like other theoretical subjects?	-		100% (3)
Are you aware of instructional models available to teach the EGD subject?	-	-	100% (3)
Have you experienced any teaching difficulty during the lesson of analytical drawing?	-	66.66% (2)	33.33% (1)

The above findings indicate that, although these EGD teachers had no teaching difficulties, they were not aware of any instructional models that they could use to enhance the students' understanding of EGD concepts. This resonates with the study by Ramaligela et al that technology teachers in particular did not exhibit comprehensive knowledge of the subject matter and its learning didactics [24]. Also, this could be attested by the observation findings presented below.

Figure 1: Analytical drawing activity.

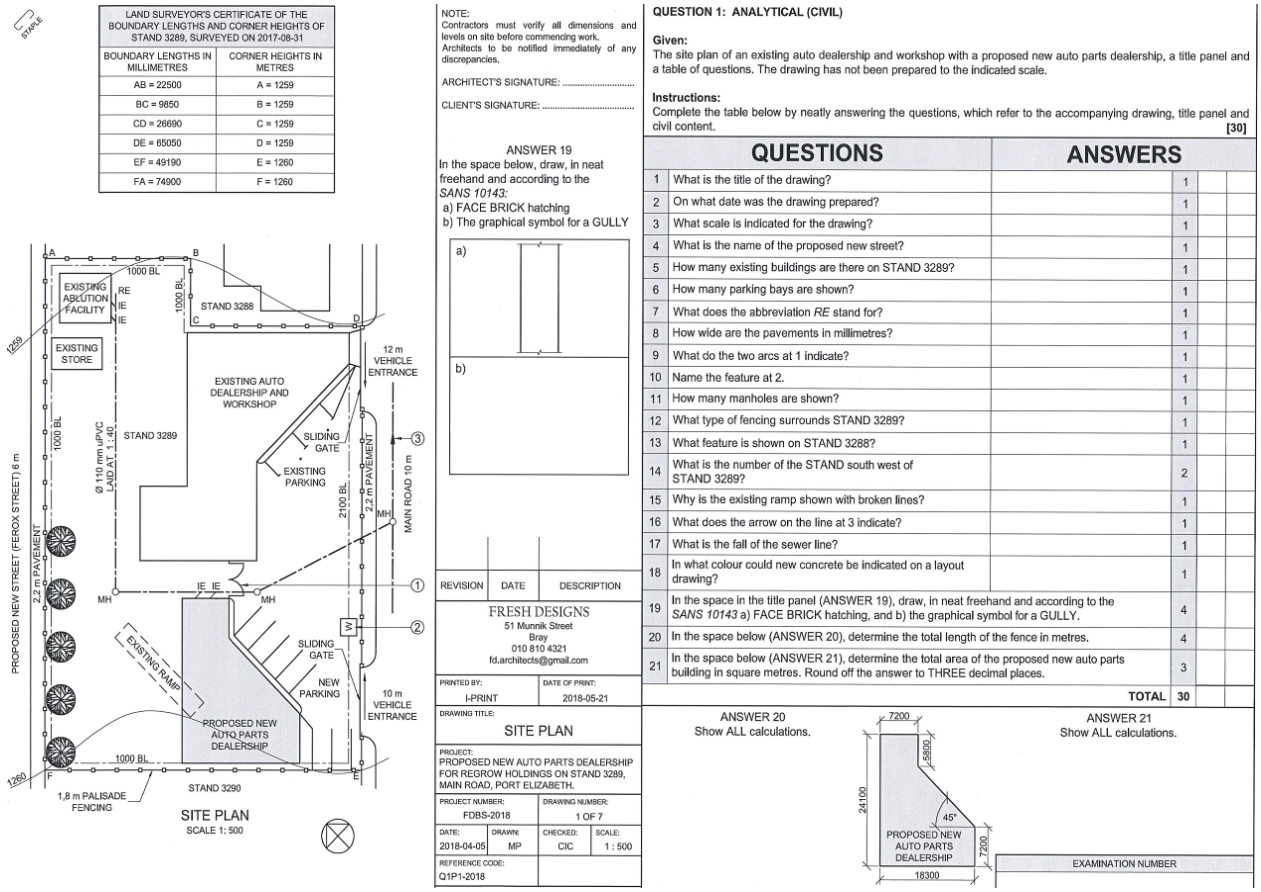

Table 2: Findings regarding instructional practices.

Concerns	Yes	No	Variation frequency
Engage - Were the teachers able to elicit students' prior knowledge?	-	o	100%
Explore - Were the teachers able to build-up from the prior to organise thinking in the learning sequence?	-	o	100%
Explain - Was there any questions asked to check understanding?	o	-	66.66%
Elaborate - Did the teachers provide opportunity for students to enhance their understanding of concepts and skills?	o	-	100%
Evaluate - Did the teachers assess students' inputs after activity completion?	o	-	100%

During observation, this study discovered that all three teachers had no planned mode of eliciting students' prior knowledge except to only give students the activity without any direction. According to Skosana [6] along with Mtshali [9], EGD is a drawing language with less emphasis on theoretical explanation. However, with regards to the content and structure of the questions, this study holds that it is possible for teachers to become more theoretical in this aspect of EGD as students need to be oriented on the plan details. As a result of the challenge in the *engage* phase, this study discovered that the teachers were unable to collectively offer opportunities for the *explore* phase. On a lighter note, these teachers were able to go around students and assist them to understand the questions posed to them. However, their way of individual assistance did not promote classroom discourse as students could not interact with one another during the lesson.

Even though two of three teachers could execute the *explain* phase, they could not ask questions and further provide resources and information to support the holistic learning of all students. In a study by Isaac and Manto, it was also evident that technology teachers find it difficult to explain technological concepts [11]. This was due to an unclear hands-on practical lesson sequence. Also, Makhubele et al made a similar observation that technology teachers have challenges with their teaching approaches [25]. On the other hand, the *elaborate* phase was well executed, since students were provided with sufficient time to apply their understanding of concepts and skills. This was strengthened

by the fact that the questions posed during the activity automatically led students to apply their understanding of symbols and calculations. The *evaluate* phase was the only phase accomplished collectively by the teachers. By means of oral interaction, the teachers were randomly asking for answers that each student had written. In some way, this ensured that students also assessed their understanding of analytical civil drawings and ultimately the teachers were able to evaluate each individual student's progress toward achieving learning goals and outcomes [14].

CONCLUSIONS AND RECOMMENDATIONS

This study conclude that teachers were unable to create a discourse through the analytical drawing activity. This was because these teachers could not align their lessons with the 5E instructional lesson style. This study found that teachers were unable to create opportunities for students to discuss, as a whole class or group, some of the aspects of the activity. For instance, question 20 of the activity required students to determine the length of the fence in metres. Given that the drawing had no label of the fence, students should have collectively analysed the appearance of the fence in the drawing and make connections with the boundary lengths and corner heights as shown in the top left table in Figure 1.

This study notes that EGD teachers preferred to attend to students individually during the activity than to teach the whole class. This was supported by the fact that teachers could only elaborate when they saw the work of each student and would not address the whole class collectively. Thus, this study holds that individual teaching does not encourage classroom discourse and it robs learners of the opportunity to reason, interpret and critically analyse drawings [9].

In order to assist EGD teachers and subject advisors on how to create classroom discourse to enhance the understanding of civil analytical drawings, this study recommends that teachers should always elicit students' prior knowledge by engaging more in verbal communication. This will assist students to understand the importance of reading drawing instructions and capitalise on questions that have more marks. Furthermore, this study presents a brief framework, which could be used in EGD classrooms to ensure that sufficient contact between students and teachers is achieved. This was motivated by the identified lack of lesson sequencing skills by the sampled EGD teachers. Thus, the following diagram is called the *Engineering graphics and design lesson sequencing diagram*.

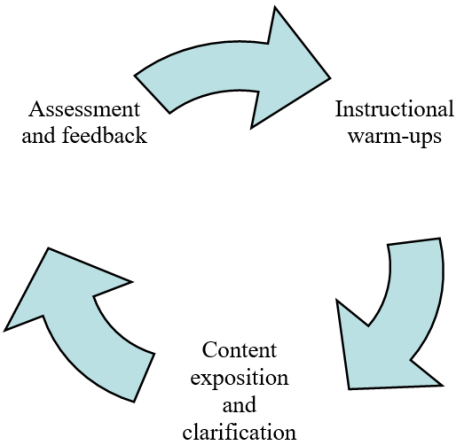

Figure 2: EGD lesson sequencing diagram.

This model begins with the *instructional warm-ups* phase. It is recommended that during this phase, EGD teachers should elicit prior knowledge and drawing skills. This may be done orally or through activity. The aim is to lead students to the understanding of drawing techniques required in that particular activity. The second phase is called the *content exposition and clarification* phase. This is the phase where teachers need to explain in detail the instructions for the required drawings and communicate the expected completion time for the activity. This will allow students to seek clarifications, analyse and interpret all the instructions given. This line of thinking was strengthened by Skosana's assertion that most EGD students find it difficult to finish drawings on time [6]. This is attributed to the lack of understanding the instructions. The last phase in the sequence is the *assessment and feedback* phase, which must not be perceived as a concluding phase, but a time period when a teacher attend to students' drawing needs, so that they may gain a complete spatial visualisation skill.

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