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Difficulties of Student Teachers in the Engineering Graphics and Design Course at a South African University: Snapshot on sectional drawing

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Engineering Graphics and Design (EGD) is a university course that teaches a medium of communication in the form of drawings. This study was undertaken to investigate factors associated with the difficulties experienced by student teachers in the sectional drawing component of the EGD course. Purposive sampling was used to select 40 students enrolled for the Bachelor of Education: Technical Education studying EGD. Questionnaires, classroom observations and focus interview were used to collect data. The results of this study reveal that students have a poor EGD background; experience difficulties in understanding sectional drawing; lack understanding of sectional drawing principles; lack knowledge of 2D/3D sectional drawing as well as poor pedagogic practices. It has also transpired that students perform poorly in the spatial visualization test. It is recommended that more attention be paid to line-work and spatial visualization exercises during teaching, using Piaget's perception of imagery theories. Specific subject didactics of technology subjects should be strengthened with these topics in order to prepare efficient and quality teachers of EGD and related subjects.

Keywords: computer-aided drawing, Engineering Graphics and Design (EGD), sectional drawing, technical drawing

INTRODUCTION

In the engineering world, Engineering Graphics and Design (EGD) is the medium of communication through drawings. It relates theory and the picture of reality, the same way as technical drawing does. EGD provides an accurate and complete picture for every object in terms of shape and size in technology-related fields (Widad & Adnan, 2000). The EGD emphasis is focused on the correct use of tools and equipment, drafting media, sketching, lettering, alphabet of lines, geometric construction, fundamentals of computer-aided draughting (CAD) and multi-view

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drawings (Widad, Rio & Lee, 2006). EGD is one of the elective courses taken by student teachers in the technology teacher education programmes at some universities in South Africa. For example, student teachers in 2nd and 3rd years of study at an Eastern Cape university who have enrolled for the Bachelor of Education: Technical Education course find sectional drawing difficult to learn and have trouble in passing it. They cite various reasons for the difficulties that they experience in sectional drawing. Their lecturers also mention difficulties in facilitating sectional drawing. These utterances, by students and lecturers alike, prompted this study to investigate factors associated with the difficulties of student teachers in sectional drawing in the EGD course at this Eastern Cape university because poor performance hampers students from progressing to the next level and eventually completing their degree within the required period.

State of the literature

- Piaget's theory of perception and imagery comprises four periods of perception, namely, the sensori-motor, pre-operations, concrete operations and formal operations stages; these four periods are essential for students' perception and visualization in the EGD course.
- The Purdue Spatial Visualisation Theory (PSVT) underpins the improvement of the spatial visualization ability in students by enabling them to visualize and draw an object accurately.
- Most teachers who teach engineering drawing or related courses do not know the theories mentioned here, that could be used by them to improve the spatial visualization skills of students studying engineering drawing.

Contribution of this paper to the literature

- A disproportionate number of students who study EGD perform poorly in the course because of the irrelevant teaching and learning methods applied at school. The use of PSVT in engineering drawing assists in the diagnosis of spatial visualisation abilities of students who study EGD and leads to the development of relevant intervention programmes.
- This study contributes to the improvement of teaching and learning EGD by applying Piaget's theory of perception and imagery and PSVT.
- Initial teacher education and professional development will benefit by the incorporation of Piaget's theory of perception and imagery and PSVT in pedagogy courses and should improve the performance of students in EGD courses.

According to Brink, Gibbons and Theron (2003), a sectional view in drawing subjects is a view where one imagines that part of the object has been removed to reveal hidden detail, while in reality nothing has been removed. They also state that a sectional drawing demands the basic knowledge and skills of EGD at a Grade 9 level of the National Curriculum Statement (NCS) curriculum, where graphic communication is studied (Brink et al., 2003). On the other hand, the main purpose of sectional drawing is to reveal the hidden details in a drawing (Moolman & Brink, 2010). The revelation of the hidden details in a drawing will assist students, draughtsmen and engineers to identify underlying components in a drawing when designing technical projects. This will enable an engineer to be able to assemble or dismantle components in a model for further machining purposes in industry.

The revelation of underlying or hidden components in a drawing is done through reading and understanding the various line-types used in EGD. According to Moolman and Brink (2010), there are ten different types of lines that are used in the entire EGD curriculum; this also applies to the school curriculum. Of these ten line-types, seven are the main ones in EGD concepts, with the other three mainly being the applications of some of the other types. A sectional drawing question could contain all seven line-types depending on its degree of complexity. This requires that drawing instruments are available to students in order for them to make sense of the sketches that they draw and participate in the teaching activity. Should students not have drawing instruments, it would be difficult for both teaching and learning to occur because, as Wells (2000) notes, when teacher and students do not work together optimally to come up with an intrinsic product, then no learning takes place.

Sorby (2009) states that any student who learns EGD needs spatial visualization skills to understand its concepts. This author suggests that those who enrol for the

EGD course need to have already attended courses related to spatial visualization skills. The spatial visualization ability has been recognized as a predictor of success in many technology-related fields, EGD included (Strong & Smith, 2002). Spatial visualization is a fundamental skill for those working and studying in the field of engineering, as well as those individuals in technology professions that work with a diversity of vector graphic tools designing in three-dimensional space and virtual environments (Branoff, 1998; Gorska, Leopold & Sorby, 2001; Yue, 2006). For this reason, spatial visualization has long been considered an essential component in careers using and interpreting graphics technologies (Yue, 2006). Yet despite the importance of this skill, large segments of the general populace do not perform well when confronted with spatial-visual relations tasks (Ben-Chaim, Orion & Yael, 1997). Traditional teaching methods and approaches do not emphasize the students' visualization skills (Widad, Rio & Lee, 2006). The EGD course in an Eastern Cape university, where this study was undertaken, consists of several topics and concepts, of which sectional drawing, with its related spatial visualization abilities, has caused students to perform poorly in sectional drawing of the EGD course. Hence, the study investigates factors, perceived by student teachers and lecturers, that create difficulties in the teaching and learning of the EGD course, with a particular focus on sectional drawing.

PURPOSE OF THE STUDY AND RESEARCH QUESTIONS

The performance of student teachers in sectional drawing has been poor for years at a university in the Eastern Cape of South Africa, thus not allowing them to complete the EGD course on time. The aim of the study was to investigate difficulties in the teaching and learning of sectional drawing of student teachers in the teacher education programme and to come up with a better way to teach and learn sectional drawing. This aim is reflected in the two research questions:

1. What are the difficulties experienced by lecturers and student teachers in the sectional drawing component of the EGD course?
2. What is the spatial visualization competence of student teachers in learning sectional drawing in the EGD course?

THEORETICAL FRAMEWORK

Piaget's perception and imagery theory assisted the study in ascertaining how students develop cognitively in understanding EGD concepts. Adopted from Piaget's four periods of perception, namely sensori-motor, pre-operations, concrete operations and formal operations , the researchers were able to determine how students' perception and visualization skills were used because these four periods form the fundamentals of mental growth (Nakin, 2003). According to this author, at the initial stage (sensori-motor), children exhibit a purely egocentric view of the world that continues into the second stage. At the third stage, children can perform reversible mental actions but only on real, concrete objects (Cockroft, 2002). During the final stage of formal operations, children not only classify, order and reverse mental operations, but can also take the results of these concrete operations and generate hypotheses about their logical relations, resembling the kind of thinking called 'scientific method' and referred to as abstract reasoning (Campbell, 2006).

According to Piaget and Inhelder (1971), children start to develop their formal operational skills at the age of 13 years, reaching their maximum potential by the age of 17, thus suggesting that students in post-secondary education are formal operational thinkers. However, recent studies have shown a high percentage of post-secondary students who have yet to reach the formal operational stage (Killian, 1979:3; Reesink, 1985:24). This has significant implications for teaching, even in higher education, since reaching the formal operational stage is a result of a combination of maturation and experience from earlier stages. While maturation might come with age, experience is most likely to be the consequence of education. Piaget's theories of intellectual development explain how individuals' understandings of the world change during development and children themselves actively construct the knowledge (Miller, 1993). Piaget (1969) suggests that perception and imagery are figurative processes which can be trained throughout the human lifespan, and as a result, the processes involved in mental imagery apply to both children and to adults (Miller, 1993; Piaget, 1973). Piaget's theories have focused more on the child and less on the external factors surrounding the child. Vygotsky, on the other hand, emphasizes the role of external surroundings on the child (Vygotsky, 1978).

According to Piaget, a child's ability to perform a given cognitive task depends on his intellectual development (Nakin, 2003). Depending on the nature of a task, a child cannot perform that task unless he is biologically mature (in cognitive terms) enough to perform it (Nakin, 2003:65). In other words, when a concept is facilitated to students, their (students') age and maturity level need to be taken into consideration. This makes certain demands on the instruction of sectional drawing and EGD as a whole. If a child cannot perform an abstract task, he should be given a more concrete (practical) task so that learning is stimulated. For example, students should first be given a drawing model that they can see and feel, especially when they struggle with the work. Only later should they be given another drawing task for reproduction, one that they do not see or feel. This strategy will need a more comprehensive understanding of line-work because line-work identifies and describes how drawings look (Benade & Van der Heever, 1994:16). Therefore, Piaget's perception and imagery theory assisted the study in observing how students developed their understanding of one EGD concept as a basis of learning sectional drawing.

METHOD

The study made use of both the qualitative and quantitative research approaches. The purpose of using mixed methods was to obtain sufficient data that augment each other in order to fully understand the difficulties encountered by sudents in acquiring spatial visualisation skills. As a result, the data collection instruments used included a questionnaire, classroom observation during the teaching and learning of sectional drawing and focus group interviews with student teachers. The interview was audio taped, with the permission of participants, to allow adequate transcription and coding.

The questionnaire contains two sections: a student's biographical data and eight (8) closed ended questions. Closed questions serve as a survey where the researchers are only interested in knowing figures (numbers) and percentages that respondents give based on each question. These closed ended questions are of a Linkert type where respondent tick the appropriate 1–4 rating where 1 is 'Strongly agree' (SA) and 4 'Strongly disagree' (SD). The quantitative data were then analyzed statistically with the aid of SPSS statistical analysis. The reliability of the questionnaires in this study is 0.7, using Cronbach's alpha reliability coefficient (Santos, 1999). The data was also collected using PSVT (Guay, 1977), which consists of three topics, each with 12 problems/questions. The three topics are (1) Developments (2) Rotations and (3) Isometric views. For the purpose of this study, Rotation and Isometric views were administered to students because they are specifically relevant to spatial visualisation abilities for sectional drawing (ibid).

Classroom observations were video recorded so that the researcher could watch them repeatedly and also send them to other experts with extensive research and

EGD experience to confirm their reliability. During observations field notes were taken. The classroom observation schedule was adopted from Staffordshire University's 'Guidelines for the Observation of Teaching' (Hammersly-Fletcher & Orsmond, 2004).

Purposive sampling was used to select 40 students in 2nd and 3rd year, both female and male of varying ages of 17–27 years, enrolled for the Bachelor of Education: Technical Education studying EGD. Fifteen students were in their 3rd year and 25 in their 2nd year. There were 6 female and 9 male students in the 3rd year as well as 10 female and 15 male students in 2nd year doing EGD. Structured focus group interviews were conducted with students (5 groups of 8 members each). Both the classroom observations and interviews were video recorded so that listening to them again helped the researcher to identify a pattern in the responses. The interviews were transcribed and themes were developed based on the questions asked; classroom observations were analyzed descriptively per item.

RESULTS AND DISCUSSIONS

Questionnaire results on students' difficulties in EGD course

For the purpose of answering RQ1 in table 1, student teachers were requested to respond to item statements measuring difficulties in the EGD course. Table 1 provides the results of a descriptive analysis (frequency, percentage, means and standard deviations) on items considered to be difficult in the EGD course. According to table 1, the item with the highest score is 'having EGD instruments' (where 93% participants answered that they 'Disagree' that they have EGD instruments), with mean score (M= 3.38) and standard deviation (SD = 0.89); have EGD background (88% participants answered that they 'Disagree' that they have EGD background), with mean score (M= 3.40) and standard deviation (SD = 0.50); understanding sectional drawing (83% participants answered that they 'Agree' that they have difficulties in understanding sectional drawing), with mean score (M= 1.95) and standard deviation (SD = 0.85); lack of understanding of sectional drawing principles (77% participants answered that they 'Agree' that they lack understanding of sectional drawing principles), with mean score (M= 2.40) and standard deviation (SD = 0.73). According to Abrahams (2003), knowledge of the principles of sectional drawing enables students to produce good sectional drawing in a step-by-step process. On lack of knowledge on 2D/3D of sectional drawing, 60% participants answered that they 'Agree' that they lack knowledge on 2D/3D of sectional drawing), with mean score (M= 1.65) and standard deviation (SD = 0.83). Chan (2007) argues that students who lack knowledge of 2D/3D concepts will experience difficulties in imagining how objects would appear when rotated in 2D

Table 1. Difficulties in EGD course experienced by students (n =40)

Statement/indicator	Agree		Disagree		Mean	SD
	F	%	F	%		
1. Understanding sectional drawing	33	83	7	17	*1.95	0.85
2. Lack of understanding of sectional drawing principles	31	77	9	23	2.40	0.73
3. Have drawing models	21	53	19	47	3.38	0.74
4. Have EGD instruments	3	7	37	93	3.38	0.89
5. Familiar with EGD line-types	26	65	14	35	1.70	0.72
6. Relevant previous topics of sectional drawing	20	50	20	50	2.88	0.69
7. Have EGD background	5	12	35	88	3.40	0.50
8. Lack of knowledge on 2D/3D sectional drawing	24	60	16	40	1.65	0.83

**Agree (1), Strongly agree (2), Disagree (3), Strongly disagree (4)* and 3D space. Most participants (65%, M= 1.70, SD = 0.72) agreed that they are familiar with EGD line-types which form the basis of EGD courses. According to Moolman and Brink (2010), drawing is a graphic language used by engineers and draughtsmen to communicate a design using symbols, dimensions and different types of lines.

Test scores on students' visualisation and spatial questions

In response to RQ2 of the study, students were given tests on the visualisation and spatial sections of sectional drawing of EGD, as shown in Table 2. The test consists of 12 questions or problems on rotation and isometric views respectively, taken from PSVT (Guay, 1977). The orthogonal rotations of 3D objects are designed to help visualise the rotation of a three- dimensional (3D) object (Guay, 1976). The isometric view is what a 3D object looks like from different views and tests the spatial visualisation skills in EGD courses (Yue, 2000).

Table 2 shows the summary of test scores in the form of frequency scores, mean and standard deviations. In table 2, 'Rotation' shows that out of 40 students and 12 problems, one student scored correct answers in all 12 problems, 5 students scored in 11 problems, 2 students scored 10 problems, with mean (M = 7) and standard deviation (SD = 3.32). The average score on 'Rotation' is 7 or 58%, which in relative terms is not an excellent performance. This is not surprising when one considers the indicators of difficulties reported in table 1. The standard deviation of 3.32 is a considerable spread of the scores by participants from the mean, as can be seen in table 2. There is a better performance on isometric views with a mean (M = 8) or 67% and standard deviation (SD = 2.74). The results on isometric views also show that there is not a great deviation of scores of most students from the average score, which indicates that most students are competent in isometric views.

Results of focus group interviews with students

Three themes emerged from the analysis of transcripts of focus group data, namely, (1) insufficient practice of EGD and sectional drawing; (2) lack of EGD background in secondary schools; (3) knowledge of the importance of line-types. These results serve as response to RQ1: What difficulties are experienced by lecturers and student teachers in teaching and learning sectional drawing in the EGD course? These themes are presented and discussed below.

Theme 1: Insufficient practice in EGD and sectional drawing

A group member from 2nd year (Siphokazi) said: 'I only practise when we are about to write a test because I don't have a drawing board and our EGD laboratory is

Table 2. Summary of students' performance scores on spatial visualization abilities

Rotation		**Isometric views**	
Frequency	**Scores**	**Frequency**	**Scores**
1	2	1	4
1	3	3	5
4	4	6	6
6	5	7	7
4	6	4	8
8	7	5	9
3	8	6	10
5	9	6	11
2	10	2	12
5	11		
1	12		
N= 40	Mean = 7 SD = 3.32	N =40	Mean = 8 SD = 2.74

open during lecturing hours and not in the evening for us to use it.' However, a group member from 3rd year (Ndiphiwe) said the following: 'I practise a day or two before the test because in our class, sir, there are four guys who understand sectional drawing from school so they help me and others but they are not always available.'

These responses are triggered by the fact that EGD lecturers rarely get to use models, simulations and metaphors to enhance learning, as outlined by Bucat (2004). This, on its own, is a difficulty in learning sectional drawing.

Theme 2: Lack of EGD background in secondary schools

A student from the 2nd year (Lindelwa) said the following in isiXhosa (translated into English): 'Er sir, I did Graphics at school but we never did this kind of sectioning and that's why I struggle big-time.' Similarly, a 3rd year student (Xolile) said: 'I did Civil Technology and Mathematics at secondary level and that's what I planned to do here in tertiary, but when I was given EGD I never knew I will come across sectioning and it is not for us in Civil Technology.'

This means that if students do not have a robust foundation when performing sectional drawing, they are likely to experience difficulties. According to Brink et al. (2003), as mentioned earlier in this paper, sectional drawing demands a basic knowledge and skills of EGD at Grade 9 level of the NCS curriculum, where graphic communication is taught.

Theme 3: Knowing the importance of various line-types

A 2nd year student (Abongile) and member of the Mechanical Technology group said: 'I know that line-work is the basis of drawing but I really don't know why other lines are so important in sectioning.' On the other hand, a 3rd year student (Amyolie) said the following: 'I do know the importance of various line-types because they help me in differentiating the features in the object.'

These responses show that students know line-types, but what these line-types represent is still not clear to them. As mentioned by Moolman and Brink (2010), line-work enables students to communicate ideas graphically in their engineering career. Consequently, line-work is the key concept in students' understanding of any drawing as the foundation of all drawing activities. Therefore, one cannot succeed or perform well in a concept if one does not play by the concept's rules.

Results from classroom observation

The results from observation serve as answer to RQ1 which seeks to understand the difficulties lecturers and students have in teaching and learning the EGD course. The results are presented and discussed focusing on the level of students (2nd or 3rd year) as well as on the lecturer's teaching facilitation.

Second year classroom observations

EGD for 2nd year students is offered twice a week for two hours ten minutes each, thus totalling four hours twenty minutes (4hrs:20mins), on Wednesdays from 8:00am to 10:10 am and Thursdays from 10:30am to 12:40pm. In this study there were 30 2nd year students with fewer females than males. For the two observation sessions, students were punctual with most of them arriving on time and simultaneously. Their lecturer was the first to arrive in class and before any lesson could start an attendance register was circulated for students to sign. Students were getting ready for learning because most of them did not use the institution's t-squares but their own drawing boards that made the class start promptly and in a more organised way. Only a few students used t-squares provided by the institution.

Even though most students have their own drawing board, they often share instruments like set-squares and compasses while most of them do not have erasers.

Drawing was innovative because there was no drawing model to which they could refer. After the day's topic was presented some students got together in a group and watched as one of them drew. At that moment the lecturer attended to those that were working on the given tasks on their own. During the students' interaction the noise level increased because of the discussions and information sharing. The result of this interaction was that some students did not complete the given tasks because of having spent most of the period at the desks of their fellow classmates. The application of line-work and its uses could not easily be observed because of this factor. However, students who understood what had been taught showed good insight into the application of line-work while the errors that they had committed, apparent after their work was assessed, related more closely to the application of line types. Furthermore, it was also observed that those who were engaged in drawing knew how to use drawing instruments. A noticeable trend was that only a few of them used a clutch pencil to draw with the majority using an ordinary HB pencil (that needs a pencil sharpener when blunt). Also, what was observed was that most tasks that were issued during the observation period were group tasks. Students were grouped into four groups of five for the tasks given to be submitted for assessment. Three sectional drawing questions were allocated the time frame of a week for submission.

The facilitator's presentation of the drawing lesson was superficial and abstract because there were no drawing models showing illustrations, simulations and analogies to stimulate learning, as required by the PCK theoretical framework (Shulman, 1986). The technique that the facilitator used was also abstract, leaving students to rely on the uses of line-types in the given drawing in order to make sense of it.

Third-year classroom observations

EGD for 3rd year students is also offered twice a week for four hours twenty minutes (4hrs 20 minutes) in total, on Tuesdays from 10:10am to 12:40 pm and Fridays from 08:00am to 10: 10am. In this study there were 15 3rd year students consisting of female and male students. For the two observation sessions, students' punctuality was excellent, with all of them being in class on time. Their lecturer was also punctual and the lessons started smoothly. The attendance register was circulated for students to sign while the lecturer was occupied with other duties like whiteboard cleaning and other lecturing preparations in an attempt to get the classroom ready for learning.

Similar to the 2nd years, most students had their own drawing boards with all four female students having drawing boards as compared to their 2nd year female counterparts. Although not all of them had drawing instruments, e.g. compasses, erasers, French and flexi curves etc., the 3rd year learning organization differed from that of the 2nd years with a slightly lower noise level. There was no model for the topic the lecturer introduced, and learning and drawing were also abstract. After the lesson had been introduced, two male students began the work with all the students gathering around them for observations and questions. The lecturer too was amongst them trying to see and assist while they were drawing. Female students happened to be the ones posing a lot of questions, showing more curiosity to understand in-depth what was drawn. At the end of the lesson, not all of the students had finished drawing what had been given to them.

The second round of classroom observations led to the announcement of a test, with the lecturer stating that he did not believe in assignments, but in tests. Completed sectional drawing tasks had irregularities, e.g. hidden details still showing, sectional lines being overlapped over bold lines and sectional lines going in the wrong direction. However, the display of quality lines was of a high standard as compared to the work of the 2nd years. Eighty percent (80%) of the students did not have clutch pencils and used ordinary pencils that required a sharpener when blunt. The 3rd year students' curiosity in learning sectional drawing was higher than that of their 2nd year counterparts. They showed greater interest in finding out how and why a drawing should appear in a specific way. At the end of the lesson, the lecturer was the first to leave and students remained behind to carry on with their drawings until the other class arrived to use the only EGD laboratory venue. This happened to be the time when a much brighter student/(s) would go to the front and give a clearer picture of what had been taught earlier in class.

The other major observation made was what Piaget describes as the mechanism by which the mind processes new information. Piaget and Inhelder (1971) state that a person understands whatever information fits into his or her established view of the world, starting from the early developmental stages, a proposal that is also supported by Nakin (2003). The concepts of sectional drawing and its drawing exercise require special attention, in that students should possess the appropriate spatial visualization ability, which is generally identifiable during the early developmental stages (Piaget & Inhelder, 1971). According to Piaget and Inhelder (1971), spatial skills are developed in three stages, namely, (1) topological skills, (2) visualizing 3D objects and (3) visualizing the concept area. These skills are acquired according to the way a child matures. The age difference of the participants ranges between 17 and 28, and it does not seem that the age or maturity of an individual brings about spatial skills development. Spatial skills need a good SMK and PCK for all of those to be infused in an individual.

From the results of these classroom observations it can be deduced that the teaching and learning of sectional drawing is not monitored to support students' developmental stages (Piaget & Inhelder, 1971), for example, a lecturer in one class left students to work alone after presenting an abstract sectional drawing lesson. This is a difficulty on its own for students to learn and master sectional drawing. Another lecturer opted for an exercise along with its memorandum for students to comprehend. This posed a problem for students because they had not been given a proper, comprehensive explanation of how line-types are denoted, what the dimensions are and what is happening in the entire drawing. Another difficulty was that students grouped themselves around the desk of a brighter and more competent classmate who drew on his own drawing sheet while the others watched. The result was that, after the lesson, only that bright student had drawn something and the rest had been merely passive spectators.

Classroom observations on lecturer's teaching activities

The observation protocol used for this study was adapted from peer observation of teaching (PoT), which is commonplace in the British higher education system as a means of enhancing the quality of teaching and learning. Both lecturers taking part in the study had obtained their teaching qualifications in the era when education policies in technical education in our country were still under review. It is well known that the education system pre-1994 in this country was based on racial discrimination, and did not attempt to produce better-equipped technical education teachers, particularly in the Black community (Makgato, 2003). The lecturers whom we observed also said that despite the fact that they had been involved in a programme to revise the curriculum many years earlier, no change had taken place.

Some common teaching aids used by lecturers included explanations and illustrations. Illustrations were presented through diagrams that were either drawn on the board or taken from the printouts that students were given to clarify certain concepts. Explanations were strengthened by pre-knowledge of isometric drawing because the models available were relevant to isometric drawing, however, this was not the case for sectional drawing (Treagust, Chittleborough & Mamiala, 2003).

Differences between the approaches of the two lecturers were revealed through the representations they used to teach sectional drawing. Lecturer A made extensive use of a demonstration and practical explanations; on the other hand, these were not observed in lecturer B's lessons. Lecturer A's sectional drawing introduction required the knowledge of previous EGD concepts. Consequently, students with a poor EGD background would find it difficult to present a sectional drawing sketch. The deduction may also be made that lecturer B lacked some content and pedagogic knowledge, as prescribed by Shulman's PCK framework (Shulman, 1986).

Lecturer A used his EGD experience by bringing in practical examples from the EGD curriculum that enabled students to perform sectional drawing exercises from those given in their study material. It is a pity that students did not have enough tasks to perform and that lecturer A spent very little time assisting students; they were left to their own devices. Lecturer B used exercises that had memorandums attached. He gave students tasks with memorandums so that they could reproduce an answer from the memorandum given to them. Students encountered problems, as follows: (1) to interpret the drawing, (2) to read the lines, (3) to analyze dimensions of the drawing, and (4) they were ignorant of some of the terminology used in the questions. Even though lecturer B did not leave the classroom, the aim of the lesson was for the students to brainstorm, which they had difficulty in doing because of their poor EGD background, as is also revealed in the questionnaire results and test performance (Table 1 and Table 2).

Students with lecturer A did not struggle as much as those in lecturer B's class. Lecturer B taught the 3rd year group whereas lecturer A was facilitating the 2nd years. This highlights a great difference between the strategies used by these two lecturers. With regard to the concepts of sectional drawing, lecturer B appeared to be oblivious to the students' poor EGD background, and assumed that they would be able to draw. His approach might have been influenced by his own limited knowledge of the content of sectional drawing as evidenced by his difficulty in facilitating the class. This is a reasonable claim to make because lecturer B relied far too much on model answers or memorandums from the teaching material that he distributed to students. Even when some students did not complete their tasks on time and others entirely failed to submit their work, lecturer B had not changed his teaching approach when the researcher observed him for the second time. He did not even change his approach to explain further when some students asked how the solutions were found while they were attempting sectional drawing. On the other hand, lecturer A integrated his knowledge of subject matter, knowledge of students, knowledge of context and general pedagogical knowledge to select and vary the manifested representations in his teaching that resulted in his well-developed PCK which led to his students' understanding. Lecturer B selected a strategy which indicates that subject matter knowledge and knowledge of students are absent from his knowledge domains which was manifest in the difficulties experienced by his students. Moreover, some of the examples lecturer B used did not work for him because his introduction to the current topic did not have a link to the previous topic. The new topic seemed isolated as if this was the first time students had encountered EGD.

The above discussions imply that teachers' manifestations of their knowledge are not tested and gauged because they cannot provide simulations, models and metaphors that could assist in stimulating learning (Geddis & Wood, 1997). If lecturers do not have textbooks and study guides for EGD, then they most likely lack curricular saliency, as discussed by Geddis et al. (1997). Some lecturers are unable to employ various assessment strategies because their knowledge of the subject matter is affected by the fact that they do not have current material and workbooks to facilitate (Rollnick et al., 2008). This translates into the lack of useful strategies that assist students to learn successfully, as mentioned by Magnusson, Krajcik and

Borko (1999). Therefore, the facilitation of sectional drawing and other EGD concepts remains theoretical, with no simulations, practical observation and concrete visualization. Lecturers still lack experience of gauging students' level of competence in spatial skills because their programme does not have a CAD component which is said to be software that assists students in learning 3D concepts which in turn provide spatial skills (Bertoline, 1991; Mackenzie & Jansen, 1998). The lecturers in this study also spent most of the lesson presentations explaining in isiXhosa rather than in English because students do not comprehend the English interpretation of questions. This also has a bearing on the reason why students fail to interpret a question accurately; they are unfamiliar with English usage which is the language in which EGD and its concepts are taught.

In conclusion, based on the presentation and discussion of the results of the observation of lecturers, it appears that the facilitation of EGD sectional drawing by the lecturers observed poses difficulties for students in understanding the content because the lecturers themselves lack appropriate knowledge of the content, as well as pedagogic knowledge, as prescribed by Shulman (1986) in PCK.

CONCLUSION

This study has succeeded in identifying the difficulties student teachers experience in the sectional drawing component of the EGD course. The results of spatial visualization tests also indicate that most students have trouble visualizing an object when it is rotated in different forms. Since students come into the EGD course with insufficient content background, more attention to line-work and spatial visualization exercises should be emphasized during teaching, using Piaget perception and imagery theories. This implies that the technology teacher education programme should empower both in-service and beginner teachers with these theories. The new revised teacher education programme at universities should strengthen the specific subject didactics of technology subjects with these topics in order to prepare efficient and quality teachers of EGD and related subjects. Drawing models for all EGD concepts need to be made available in order for learning to be concrete. Students should be encouraged to buy drawing instruments in order to be fully occupied during drawing lessons and practices. There should be regular assessment in sectional drawing so that the teaching and learning barriers experienced by students can be easily and promptly identified.

The limitation of the study is that it was based on a university in the Eastern Cape; its results may not be generalized to all student teachers in an EGD course countrywide. However, due to the limited number of universities offering this course, there is no doubt that the results would be applicable to other universities. Finally, it would be interesting to pursue this topic by means of a large-scale investigation that would include all student teachers in the EGD course across all universities offering a BEd programme, with a view to understanding the challenges experienced by students in the EGD course.

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