# *PROSPECTIVE TEACHER'S PERCEPTIONS OF LEARNING 3-D DESCRIPTIVE GEOMETRY: INSIGHTS FROM A KEY INFORMANT*

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## Introductory overview

There is a growing recognition that elements of heuristic significance play a large part in practical 3D descriptive geometry when a graphical method of solving space or solid analytic problems is employed (Slaby, 1976). Some of these elements are related to personal development, as the ability to understand abstract geometrical concepts evolves throughout one's life.

Prospective teachers' perceptions about the professional learning of descriptive geometry may vary in relation to solving problems of 3D space via a 2D drawing plane with the use of different projecting methods (Bakó, 2006). Solving problems of spatial dimensions requires a creative imagination, space analysis skills and visualisation, which themselves can be harnessed and taken to another level of understanding through practice. In doing so, there is a use of the projecting drawings, which are solely intended to interpret the spatial relation, solve problems and offer solutions (*C.f.* Stachel, 2005:1).

A variety of projecting methods in geometry have the main purpose to represent spatial objects on a drawing plane. For the purpose of systematisation in this study, from a comprehensive survey of these methods show that can be summarised in three categories: central projection, axonometric projection, and methods of descriptive geometry (Bakó, 2006).

Central projection consists mainly of one projecting plane that is reliant on one or two centres from which emanate the lines of sight. In one-centre projection the

purposeful use of deformation can solve certain geometric problems; whilst two-centre projection uses obliquity, which can interfere with good representation.

Axonometric projection is the most extensively used method of projection in schools and teacher education institutions. It depicts parallel projections instead of the concurrent projecting lines used in central projection. Conversely, the methods of descriptive geometry use double projections, which can be extended to a third projection, both positioned orthogonally around a reference line.

To solve practical problems of spatial dimension, the fundamentals of methods of geometry must be understood. These encompass, *inter alia*, the following aspects:

- Points in a 3-D space;
- Lines in a 3-D space;
- Plane surfaces in a 3-D space;
- Three-dimensional spatial relationships of lines and planes;
- Rotations of geometric elements;
- Location of points and tangent planes on geometric solids and surfaces;
- Intersections of common geometric solids and surfaces;
- Development of surfaces and geometric solids.

(Slaby 1976).

These fundamentals inform descriptive geometry programmes, such as those that the Pedagogical University (UP) of Mozambique implements:

- Descriptive geometry notation;
- Two-dimensional plane and graphical representation;
- Three-dimensional relations and problems;
- Points and lines (including visibility);
- Angle measurements (perpendicularity, linearity and parallelism);
- Rotation techniques;
- Surface development;

- Planes (including true size, oblique, piercing points, parallel and perpendicular planes, dihedral angles, and revolution or rotation techniques);
- Intersections (Point and line, line and line, point and plane, plane and plane);
- Solid geometry (which includes polyhedra [platonic solids, prisms and pyramids], and non-polyhedra consisting of sphere, torus, cylinder and cone);
- Theory of section;
- Theories of shades, shadows and cast shadows.

(Nhiuane et al 2003).

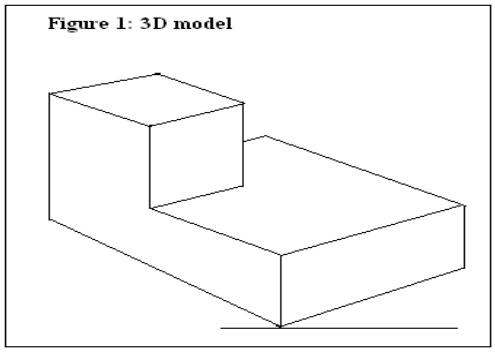
Figure 1: 3D model

However, although not necessarily exhaustive, such a list of geometry-related content is expected to lay a good foundation upon which student-teachers develop their spatial reasoning, visualisation skills and fine motricity (rigorous representation).

Besides this, in learning descriptive geometry professionally one develops an intuitive ability to identify the best viewing direction for good representation and thus the easier solution of spatial problems as in the above 3D mode* shown in figure 1 in simple axonometric projection. Thus, modelling and model manipulation are key skills worth mastering in order to be able to 'see' through three-dimensional (3D) space and render this knowledge in graphical form (2D) on epure (also known as a drawing plane shown in the 2D representation in figure 2*).

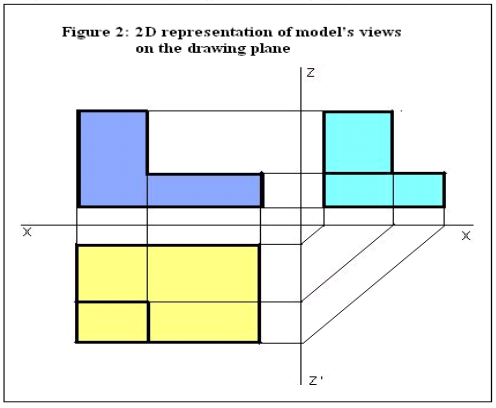

Figure 2: 2D representation of model's views on the drawing plane

Computer-mediated learning comes into play here as an enabling resource that enhances this manipulative and iterative process between 3D and 2D, which the UP's Faculty of Science and Mathematics has decided to embrace (Nhiuane et al. 2003). However, it is appropriate to succinctly review some relevant influential factors in descriptive geometry education.

Firstly, it is widely recognised that the teaching of descriptive geometry has been confined to technical schools in many countries. It is not surprising to find that the best candidates for higher education geometry courses are invariably those coming from these type of schools. In Mozambique, the teaching of descriptive geometry as a formal curricular component was introduced in schools in the late 1970s, particularly in teacher education institutions and public universities. However, the majority of these were short courses, which led to a poor professional foundation for graduates, as was found in an evaluation of the education system study (INDE 2005).

This situation also led to calls for a renewal of the curriculum, not only to revise the outdated knowledge-based aspects of the programme, but also to give it a broader philosophical perspective as well as greater time allocation within the curriculum. Practice is also central to geometry curriculum. In its report, INDE (2005) suggested that a sound model of the teacher education curriculum should capitalise on these aspects if secondary schools are to deliver satisfactory results in the subject. Furthermore, the sound initial preparation of prospective geometry teachers should enrich their experiences on becoming professionals.

Becoming a good teacher of geometry stems from a plethora of training efforts against the backdrop of conditions such as a career development mind-set, psychological

preparation, school development, students' background and needs, the school's ecology, time constraints, and the financial resources for post-preservice training 'refreshment' and courses (*c.f.* Villegas-Reimers and Rameirs, 2000).

These conditions therefore boil down to an understanding that the teaching and learning of descriptive geometry may benefit greatly from its mainstreaming in the mathematics curriculum only if there is a policy review and curriculum renewal in favour of a system that provides room for investigative learning in a more practical way, so that the status of the teachers and subject is raised within the mathematics domain (Bishop, 1980). Sufficient resources (time and materials) would need to be deployed for better student-teachers learning of descriptive geometry.

In order to further analyse respondent's perceptions concerning the learning of geometry, a grounded theory study was conducted using six focus group interviews along with ten semi-structured interviews. The participants were selected randomly from amongst student-teachers and teacher educators/school managers. The approach to data collection that was employed was guided by the research questions (Punch 2005:159).

This paper presents data from an interview with one of the study's key informants, Mr. Christopher Elias (CE) (pseudonym), who is a member of the Faculty of Science and Mathematics at Pedagogical University (UP) in Maputo. As the department's descriptive geometry lecturer, Mr. Elias is involved in most policy-making decisions, curriculum specification and the training of secondary school descriptive geometry teachers.

The aim of the interview was to characterise Mr Elias' perceptions of student-teacher learning of descriptive geometry. An interview format was chosen that asked neither closed questions nor risked bias from researcher preconceptions. The aim was to

explore the respondent's perceptions of geometry education by listening to his own words, giving him the opportunity to talk and speak his mind freely (Matusse, 1998:235), as follows:

**Interviewer (DDC): How do you develop student-teachers' competencies to attain the expected results in descriptive geometry?**

**CE:** In reality, it is highly complex for student-teachers to study descriptive geometry. This subject is extremely demanding. The most we can do initially is to assign them more investigative work. Then we provide them with reading lists. When introducing a topic, they form groups of five or six student-teachers. They review the theoretical concepts and conduct a small investigative task.

**DDC**: **Is this a monograph?**

**CE:** It may be comparable to a monograph. This is a kind of initial research study to see how much they understand things. A student is supposed to collect data and solve problems, then and in the classroom we discuss the findings to see whether they understand the concepts, since we know that descriptive geometry is intended to equip them to be able to see through space and to be able to use their imagination.

**DDC**: **Does this work promote students' autonomy and independence?**

**CE:** Oh yes, yes.

**DDC**: **How does this relate to the learning process?**

**CE:** It is indeed student-focused learning. The student should actively be involved in learning whilst the lecturer monitors the activities, instructing them to follow the correct steps and paths.

**DDC**: **How do you assess this teaching method?**

**CE:** This method we are now introducing is, in reality, a bit difficult for students. However, they must be familiarised with it. The thinking process lies in students' hands rather than the lecturer's. The lecturer is a facilitator. We aim for even higher knowledge here, as opposed to practices in secondary schooling.

**DDC**: **Does it produce any good results?**

**CE**: Oh yeah, it does! [Emphatic].The level of accomplishment is very good. However, when group work is assigned, three or four students are usually hard-working and a few others are just passive learners [hum!]. When it comes to presenting the group work, there are real difficulties. What I do is to select students randomly to present the work.

**DDC**: **What happens then?**

**CE**: I choose them randomly to present the group work, as I said. The next time all the students come prepared individually to present their work, since they know that the teacher will not allow them to choose who to present the results.

**DDC**: **In that case, what are the topics in which students experience difficulty in descriptive geometry?**

**CE**: For instance, in this semester we have seen the introduction to geometry: points, lines, planes. However, the intersections of lines with planes and intersections between planes are complex, and require more time for explanation and practice.

**DDC**: **How do you solve this problem?**

**CE**: We produce models to help students to develop their creative imagination and rigorous thinking through a visualisation process. According to our curricular regulations,

we are supposed to make models and posters to show how things work to solve space or solid problems on the drawing plane. Students do this exercise too.

**DDC**: **In your view, how well do the students learn?**

**CE**: In my opinion, only fifty per cent managed to achieve the learning objectives. The other half requires remedial activities.

**DDC**: **How does the curriculum help to promote professional competencies in training good secondary teachers of descriptive geometry?**

**CE**: At end of the course, I believe that professional competencies have developed. In terms of output, our graduates are equipped to teach all lower secondary school levels. We also equip them with additional knowledge and skills to teach upper secondary grades, since we know that the country lacks descriptive geometry teachers. Let me explain it better. The curriculum aims for them to be able to teach grades 8, 9 and 10 only. We offer additional competencies for them to teach students at grades 11 and 12.

**DDC**: **What are the topics taught at this institution to student-teachers who will teach in upper schools?**

**CE**: We introduce the whole field of descriptive geometry, from the theory of points up to the intersections of lines with solids. We recognise, however, that some students were not taught these things during secondary school, so we give them further input.

**DDC**: **How do you manage time in teaching descriptive geometry?**

**CE**: Descriptive geometry is taught in two semesters. They take this subject at the end of the second year and the beginning of the third year. They have six hours per week, and each training session takes 50 minutes. I think that time is sufficient for the amount of knowledge content delivered to students and for the purposes of the programme.

**DDC**: **What is your understanding about student-teachers' confidence in teaching descriptive geometry?**

**CE:** Not all students can get acceptable results to give them the confidence to teach this subject. At least fifty per cent of students come out more or less confident to teach at high school. In my own professional experience, even for lower secondary! Some graduates will not teach to level 10 though. They may fear to teach grades 10 and 12 students because they are in the final-exam grades.

**DDC**: **Why are they not so confident?**

**CE**: I am not sure whether it is lack of confidence or something else. Teachers at grades 8 and 9 are very flexible. However, for teaching at grade 10, I do not know what is happening, they are so fearful! Why it is happening, I do not know really! They receive a very good training and are well equipped before leaving.

**DDC**: **Isn't it a lack of more practice during the training and at school?**

**CE**: It might be, but we have no evidence to support that as a contributing factor for such a lack of self-esteem.

**DDC**: **What is it then, if is not lack of practice?**

**CE:** I think that the most likely source of the lack of confidence is the insufficient time devoted to school-based training. Besides this, during practice, they are often assigned grades 8 and 9 but not 10. This is more to do with the school where the practicum takes place and what the school leadership decides are the places available for student-teachers at the time of the placement. Such placements may not necessarily meet training needs. It would be best for them to practice with the final years; that is, grades 10 or 12.

However, the school managers, heads and deputy-heads think that they are 'novice' teachers; therefore, they are not entitled to teach students in the final years, so instead they are given the lower levels. Another question which we cannot underestimate is to do with the exam component. Grade 10 and 12 are the exam years at college. The 'novice' teachers know effectively what the responsibilities are at level 10 and 12. They prefer to take classes with no exams.

**DDC**: **Is this because in these lower grades the teacher does not carry such a burden of guilty?**

**CE**: Yes. When it comes to exams, they are supposed to write reports; they are responsible to society or even to the whole world. There are no exams for grade 8, for instance. There is always concern about exam results every year. Therefore, newly trained teachers rule out grades with exams for fear of poor results.

**DDC**: **Is this a kind of probation phase for those who are at the 'beginning' of their careers?**

**CE**: Yes indeed! It is not wise if they are immediately posted to teach grades 10 and 12. They are actually right to see this as too much responsibility at the beginning of a career.

**DDC**: **How do we help novice teachers to build their teaching confidence?**

**CE**: Grades 10 and 12 are the final years of secondary schooling. When beginning in this profession all student-teachers need help and support. Nevertheless, they would prefer to teach grades 10 and 12 in their second year of teaching experience.

However, in the current situation, anyone who is posted in one province is given classes at grades 10 or 12. They have to take responsibility, as I mentioned. I remember during my training in the faculty of education, my didactic lecturer once said that you

need to have a gradual growth in relation to certain positions in schools to be a good professional, and he advised us not to take different grades at the same time in the first years of teaching.

**DDC**: **What do you mean by not taking different grades at the same time?**

**CE:** Just one level or grade. The teaching community then plays a large role in helping the teacher to integrate professionally within the school. After all, it is a matter of support for teaching.

**DDC**: **How is ICT taught here?**

**CE**: Student teachers have ICT and traditional components during training. There is an exchange between the manual work and the use of ICT. This boils down to integration and linking to other areas of knowledge.

This also takes us on to professionalisation. Most of the time we question whether or not our students are able to use their knowledge in their lives. In relation to these new technologies, again our graduates have sound training because the study curriculum itself integrates both traditional methods and the use of ICT. They are very well equipped. At end of their course they have, a practical vision and have developed skills for contributing to science development.

Now, where is the problem? When the graduates are posted in schools, they will not find a use for their professional competencies because the district education services do not meet their professional needs. The only available computer will not be for their use. We are at a phase in which growth is not uniform. The growth of the university, its curriculum most of the time is not in step with what happens out there in schools. The teacher should then investigate new ways of being in the profession.

**DDC**: **Do you use any geometry software for teaching?**

**CE**: They learn how to represent some geometric forms using AutoCad, which is installed in our computing clusters. All our descriptive geometry teachers learn how to make graphical representations using this software.

**DDC**: **What is the philosophy of the descriptive geometry programme?**

**CE:** We concentrate on demonstration and practicing through rigorous representation. However, descriptive geometry is a cross-curricular area. We think that descriptive geometry could be taught in other courses, because it helps the creative imagination. How can a chemistry teacher become a good teacher if he does not understand how molecules float in three dimensions, without knowledge and skills in descriptive geometry? Surely, he must have the practical 3D spatial training which descriptive geometry offers.

**DDC**: **What are the student-teachers' perceptions about learning descriptive geometry professionally?**

**CE**: In fact, there are graduates who leave with high levels of confidence. Some say "I am able to teach, I have confidence in this subject". Nevertheless, there are very few who say they want to teach grades 11 and 12. However, teachers are proud to teach these final years, as it seems to grant an elite status in the school.

However, if you look at these two levels, in lower and higher schools in terms of the approach used, to teach at lower grades is demanding, you need to be an individual with lots of initiative. Lower secondary level involves more visual education, more spontaneous abstraction which is related to technical drawing, whereas at high school things are more precise and rigorous. In the latter, you have data and there is no space for

subjectivity. In descriptive geometry, you have concrete points, lines, planes and intersections and projections which evolve in simultaneous interrelation as a process.

**DDC**: **Any thoughts on the results of this programme?**

**CE**: The results are encouraging. Descriptive geometry was overlooked for years when the social science subjects became predominant, but now it is experiencing a surge. This subject offers a valuable contribution to society.

**Concluding remarks**

It is clear that mathematics/geometry teachers need to have a deep knowledge of content-related aspects of this subject if they are to be successful teachers. To a large extent, this is highlighted in this interview. However, it is important to stress that there is a need for policy makers and curriculum bodies to act, in interest of appropriate curriculum renewal measures, which can inform and offer new perspective to practitioners for intervention in preservice education.

While geometry-related content matters, to arrive at decisions concerning what is to be taught or what ought to be emphasised in laying a good foundation in geometry education in teacher education institutions, represents a serious challenge. In this study, the initial findings concerning the respondent's perception of learning geometry emerged. These are sixfold: (i) The practical 3D descriptive geometry programme, (ii) learning process, (iii) learning activities, (iv) teaching methods, (v) the role of teacher educators and (vi) becoming a geometry teacher.

Put briefly, the first category includes the goals and philosophy of teaching geometry at teacher education institutions, while the second consists of teaching and learning geometry procedures such as practice, time and the language used for learning

geometry. The third category includes aspects concerning the nature of the learning activities followed both by the trainees and by teacher educators.

The fourth category concerns with approaches to teaching drawn from the pedagogy of geometry. A 'hybrid' system was perceived to be most applicable, where the lecture format, group work and self-study during the course were used interchangeably and, at times, were complementary to one another. The role of the teacher educator the fifth category involves all of supporting and facilitative tasks performed by them. The final category, becoming a geometry teacher, involves a number of college-based and school based activities.

To conclude, these categories are not self-explanatory. However, they represent the passages 'quoted' from respondents' comments and 'negotiated' with them to establish their face and content validity. The main recurrent themes were sought in terms of respondent's perceptions, difficulties identified and solutions offered, in line with the methodological approach of grounded theory. The analytic procedure that governed the study was iterative and interchangeable in each stage of method of the data collection. Although the semi-structured interview technique was open-ended, it helped the researcher to probe further and understand respondent's perceptions of geometry education. The study results may be relevant to geometry learning practices, however, call for learners' specific situation and require further analysis.

**References**

BAKÓ, M., 2005. Different projecting methods in teaching spatial geometry. *In: 3rd European society for research in mathematics education, 28th February - 3rd March 2003 Bellaria.* Tolouse: Université Paul Sabatier, 1-9.

BISHOP, A.J., 1980. Spatial abilities and mathematics achievement. *Educational studies in mathematics,* 11(3), 7-16.

INDE, 2005. *Proposta de estrutura para o ensino secundário geral.* Maputo: INDE, (DOC/08/05).

MATUSSE, R., 1998. *The language policies and practices in Mozambique: The case of the changana/ronga radio journalists.* Thesis (PhD). Newcastle University.

NHIUANE, E.P., SAMO, P. CARREL, F.S., 2003. *Proposta curricular do curso de bacharelato e licenciatura em ensino de desenho*. Maputo: UP, (DOC/02/03).

PUNCH, K.F., 2005. *Introduction to social research: Quantitative and qualitative approaches*. 2nd ed. London: SAGE.

SLABY, S.M., 1976. *Fundamentals of three-dimensional descriptive geometry*. 2nd ed. London: John Willey & Sons.

STACHEL, H., 2005. Descriptive geometry on today's engineering curriculum. *Transactions of FAMENA* [online], 29 (2). Available from: http://famena.fsb.hr/famena.php?lang=eng&famena=19 [Accessed 27 July 2007].

VILLEGAS-REIMERS, E. & RAMEIRS, F., 2000. *Professional development of teachers as lifelong learning: Models, practices and factors that influence it*. Washington D.C.: Harvard University.

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[*] Projections' measures are estimates for illustration purpose only.