6. INFLUENCE OF GEOGEBRA ON PROBLEM SOLVING STRATEGIES

This chapter reports on our research findings about the influence of GeoGebra use on twelve secondary students’ problem solving strategies in plane geometry. Using multiple data sources, we analyse the complex interactions among GeoGebra use, students’ prior knowledge and learning preferences, and the teacher’s role, under the theoretical perspective of instrumental genesis. We identify three levels of instrumentalization and instrumentation and provide specific cases to illustrate students’ use of GeoGebra and their evolving mathematical conceptions in relation to GeoGebra tools. In general, the use of GeoGebra helps students enhance their mathematical understanding by enabling alternative problem resolution paths, and, in some cases, help diagnose their learning difficulties. We further discuss implications for future GeoGebra use and classroom-based research.

INTRODUCTION

This study is related to research about the integration of computational technologies in mathematics teaching, in particular, the use of dynamic geometry software in the context of students’ understanding of analytic geometry through problem solving. In this research we focus on the interpretation of students’ behaviour when solving plane analytical geometry problems by analysing the relationships among software use, paper and pencil work, and geometrical thinking. Many pedagogical environments have been created such as Cinderella, Geometer’s Sketchpad, Cabri géomètre II, and GeoGebra. In this study we focus on the use of GeoGebra because it is free dynamic mathematics software and its focus is not only on geometry, but also on algebra and calculus. Moreover, this may distinguish Geogebra from other geometry software. GeoGebra links synthetic geometric constructions (geometric window) to analytic equations and coordinates (algebraic window). We analyse secondary students’ problem solving strategies in both environments: paper and pencil and GeoGebra. As stated by Laborde (1992), a task solved by using dynamic geometry software may require different strategies than those strategies required by the same task solved with paper and pencil, which affects the feedback provided to the student. In this study, we consider the following research questions:

– What is the relationship between students’ work in both environments?
– How does the use of GeoGebra interact with the paper-and-pencil skills and the conceptual understanding of 10th grade students when solving plane geometry problems?
We analyse and compare resolution processes in both environments, taking into account the interactions (student-student and student-GeoGebra), through the instrumental approach (Rabardel, 2001). The primary purpose of our research is to offer didactical knowledge in order to understand the ways in which the use of dynamic geometry software can help promote argumentation abilities in secondary school geometry. Specifically, we will:

– Characterize students’ resolution strategies for the proposed problems in both environments.
– Analyse the instrumentation and instrumentalization processes in order to characterize different behaviours among the students.
– Explore the influence of using GeoGebra (conceptual understanding, visualization, resolution strategies) on each type of student.

THEORETICAL FRAMEWORK

We consider different approaches for our theoretical framework. The main theoretical approaches are the instrumental approach (Rabardel, 2001) and the cognitive approach (Cobo, 1998). We also specify some terms in what follows.

According to Kieran and Drijvers (2006), the perspective of instrumentation is a theoretical framework that is fruitful for understanding the difficulties of effective use of technology, GeoGebra in this case. The instrumental approach for using tools has been applied to the study of Computer Algebra System (CAS) in the learning of mathematics and also to dynamic geometry systems. In our research, we apply this framework to the use of GeoGebra, which is a free dynamic geometry software environment that further provides basic features of CAS. The instrumental approach distinguishes between an artefact and an instrument. According to Vérillon and Rabardel (1995), it is important to stress the difference between the artefact and the instrument: An artefact is a tool, which could be a physical object, a calculator, or a computer program used by a subject to perform a task. An instrument is a mental construction built by the subject from the artefact; so an instrument is a psychological construct.

The process of transforming a tool into a meaningful instrument is called instrumental genesis. During the instrumental genesis, the student builds up mental schemes. This process is complex and depends on the characteristics of the artefact, its constraints, and affordances, and also on the knowledge of the user. This process of instrumental genesis has two dimensions: instrumentation and instrumentalization.

Instrumentation refers to the process by which the affordances and constraints of the software influence students’ problem solving strategies and their emergent conceptions of the problem situations. According to Vérillon and Rabardel (1995), instrumentation involves forming utilization schemes that provide a predictable and repeatable means of integrating an artefact and the corresponding actions. Instrumentation comprises the rules and heuristics for applying an artefact to a task, through which the task becomes meaningful to the user. We will distinguish, in the analysis of the students’ resolutions, three levels of instrumentation in