# TOUCH-AND-GO IN LINEAR ALGEBRA AND ANALYTIC GEOMETRY: HANDS-ON APPROACH AS A LEARNING STRATEGY IN CASE OF VISUAL IMPAIRMENT

***Abstract:*** *The perceptual strength in learning styles refers to obtain knowledge most easily by different sensory systems. Discovering the perceptive strengths and weaknesses of each student and finding ways to optimize their learning is always a challenge for the professor. In extreme cases such as in the visual impairment touch-and-go approaches can be an alternative. This paper aims at sharing the usage of tactual resources as a learning strategy in a case of visual impairment, developed by a group of professors for supporting classes of Linear Algebra and Analytic Geometry at Sorocaba Engineering College (Faculdade de Engenharia de Sorocaba - FACENS). As a result, there was ease of handling tactile resources by the student, considerable gain in understanding the theoretical subjects and of practical cases analyzed in classroom. According to professors' perception, the concrete experimentation by using the touch-and-go strategy provided satisfactory support for the classes. Therefore, the usage of touch-and-go by means of the tactile resources can be considered as a promising approach as a learning strategy in cases of visual impairment.*

***Keywords:*** Learning strategy. Visual impairment. Hands-on. Analytic geometry.

# 1 INTRODUCTION

> Teaching-learning processes have always existed as a natural process resulting from different forms of social interaction, from simple observation by the most rudimentary animals until those by means of the most sophisticated man-made technological tools (BRESSANE; RIBEIRO; MEDEIROS, 2015, 39p.).

The perceptual strength in learning styles refers to obtain practical and theoretical knowledge most easily by hearing, seeing, verbalizing, or actively experiencing. Naturally, the learning process results from a combination of different sensory and mental abilities, but according to the biological characteristics of each individual some of them can be more effective than others (ROGOWSKY; CALHOUN; TALLAL, 2015).

Discovering the perceptual strengths and weaknesses of each student and finding ways to optimize their learning is always a challenge for the professor. In extreme cases, mental and physical impairments may partially or totally affect a particular sensory ability, as occurs in cases of visual impairment, in which touch-and-go approaches, i.e, teaching and learning with tactual resources can be an alternative in replacing the visual perception (GALASSI; AKOS, 2017; CAMARGO, 2010; MANTOAN, 1997).

Some experiences have been reported in the literature (XAVIER, 2018; SOBRAL et al., 2017; MARAVALHAS; BASTOS, 2015; FONTES; CARDOSO; RAMOS, 2012; CAMARGO, 2010; CAMARGO; NARDI; VERASZTO, 2008; COSTA; NEVES; BARONE, 2006). Camargo (2010) analyzes the communication difficulties between professors and students with visual impairment. In conclusion, the author emphasizes the importance of creating adequate communication channels as a basic condition for the inclusion of these students.

Maravalhas and Bastos (2015) pointed out the use of inclusive tools and resources as an alternative to overcome barriers and enable autonomy of students with visual impairment. In this sense, Xavier (2018) highlights mathematics as a component of great visual character, and describes the use of a hand-held calculator adapted for visually impaired students.

Fontes, Cardoso and Ramos (2012) share an experience on the teaching-learning process of graphics in physics classes. Such authors describe the use of the 'multiplane'; an educational kit specialized for tactile perception, as a substitutive alternative to visual perception with satisfactory results. Sobral et al. (2017) describe the use of Role Playing Digital Games as a tool for learning the visually impaired.

Despite these examples, there is still a few number of outcomes reported in the literature on the inclusive teaching-learning of visually impaired students (FONTES; CARDOSO; RAMOS, 2012). Therefore, the present paper aims to share a touch-and-go approach as a learning strategy in a case of visual impairment, developed by a group of professors for supporting classes of Linear Algebra and Analytic Geometry in Sorocaba Engineering School (Faculdade de Engenharia de Sorocaba - FACENS).

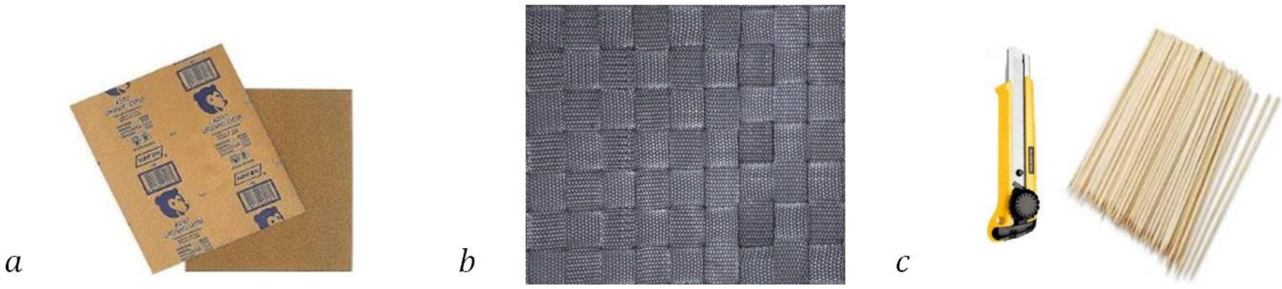
## 2 TEACHING-LEARNING STRATEGY IN CASE OF VISUAL IMPAIRMENT

The teaching-learning strategy addressed in this paper is based on two set of touch-and-go resources. The first one corresponds to tactile resources built by professors of FACENS, using low-cost materials. In turn, an educational kit specialized for tactile perception has been also used during the classes, as described ahead.

### 2.1 Tactile resources built using low-cost materials

Low-cost materials used in the construction of tactile resources included a wood sanding paper (Figure 1a), wire structure coated by a cloth woven together (Figure 1b), wooden sticks and a stylus (Figure 1c). The woven wireframe structure was employed for providing the tactile perception of a Cartesian plane in the representation and operations with vectors.

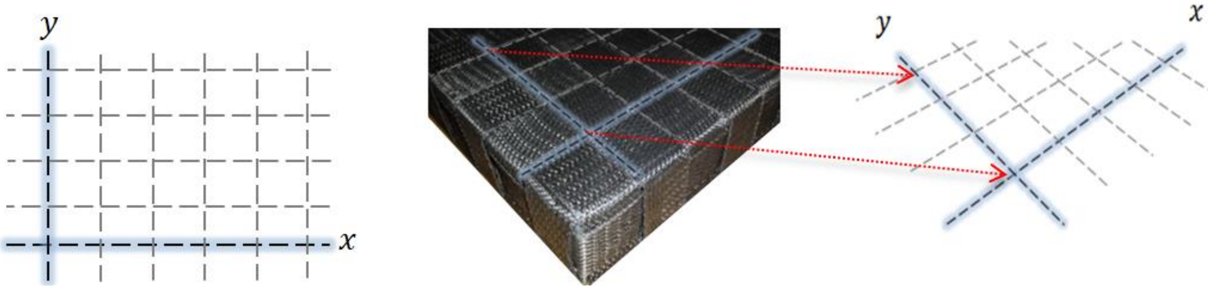
Figure 1 – Materials used in the composition of the tactile resource.




Source: produced by the authors.

The texture of the wire structure coated by a cloth woven together, highlighted in Figure 2, sought to simulate the partitions of the orthogonal decomposition bases (x0y), as well as the pairs of Cartesian points (x, y) formed at the intersections of these partitions.

Figure 2 – Tactile Simulation of the Cartesian plane with the wire structure coated by a cloth woven together.




Source: produced by the authors.

The student's handling of the wooden sticks sought the tactile perception of the representation of the vector as a straight line, as well as working the concept of a module associated with the length of these sticks (Figure 3a).

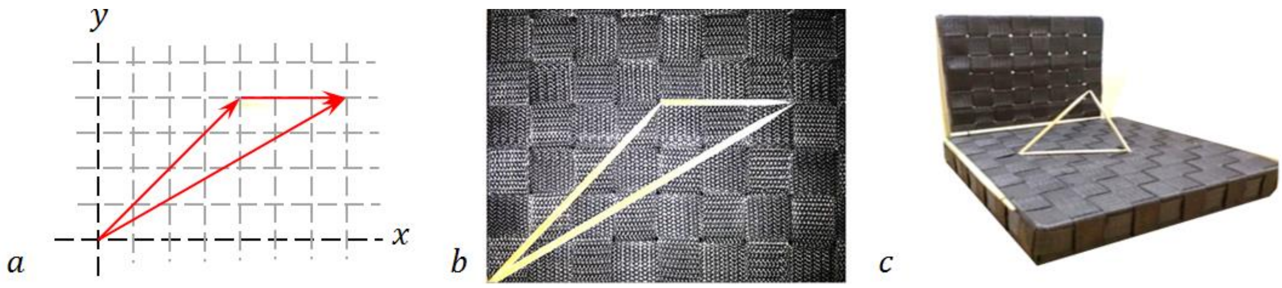
Figure 3 – Tactile simulation of the vector with wooden sticks.


Source: produced by the authors.

Maintaining the straight stick shape at one of its tips allowed us to work on the vector origin concept (Figure 3b). In turn, the use of the stylus and the sandpaper made it possible to accentuate the thinning of the other end of the stick and, in this way enhancing the tactile perception of the extremity and to work the concept of direction (vector orientation).

As a result from the usage of touch-and-go resources during the classes, the structure coated by a cloth woven together and the wooden sticks allowed to work the tactile perception of the geometrical methods and operation with vectors (Figura 4a), both in the 2D-plane (Figure 4b) and in 3D-space (Figure 4c).

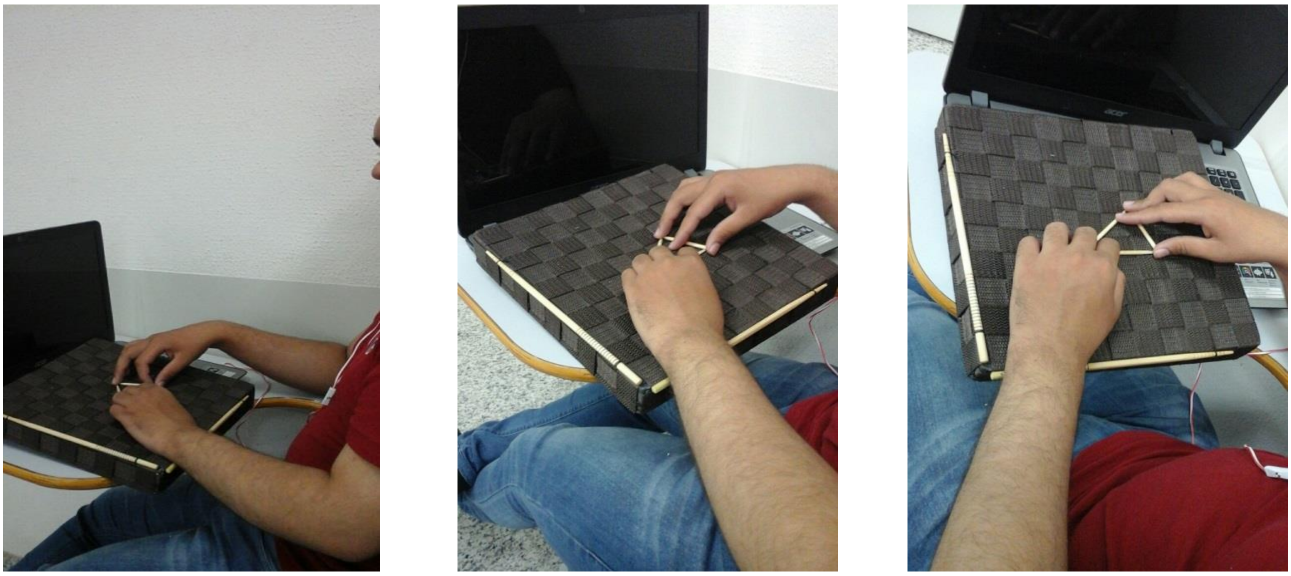
Figure 4 – Usage of touch-and-go resources for tactile perception in 2D-plane (a) and 3D-space (b, c).




Source: produced by the authors.

The usage in class of the resources described gave quite satisfactory results. By consulting the visually impaired student at the end of the classes, s/he reported ease of resource handling and considerable gain in understanding the concepts and operations worked in the classroom (Figure 5).

Figure 5 – Use of tactile perception resources in the classroom by the visually impaired student.



Source: produced by the authors.

### 2.2 Educational kit specialized for tactile perception

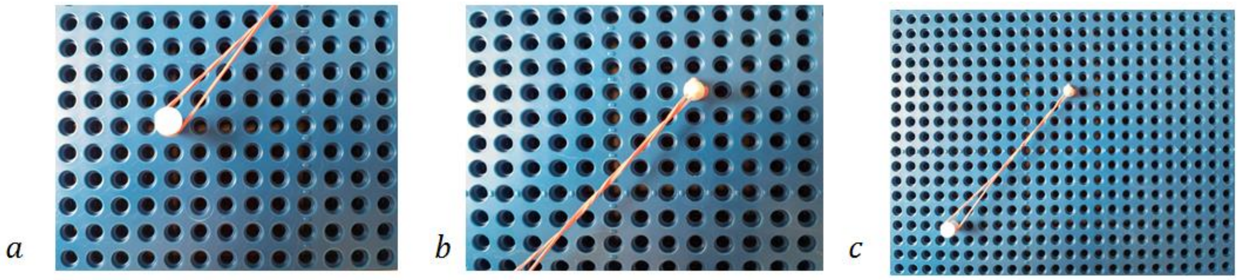
In th mid-2000's, the Multiplane Classroom Kit was developed by professor Rubens Ferronato, who was facing difficulties in teaching math to a blind student. Since then, this kit has been upgraded and traded for educational purposes, especially for concrete experimentation of theoretical concepts (Figure 6).

Figure 6 – Commercial multiplane classroom kit.


Source: produced by the authors.

The commercial kit includes a perforated plate, which can be used as Cartesian plane (Figure 6a), a set of pieces to construct geometric elements (Figure 6b) and graphical representations (Figure 6c). As represented in Figure 7, these components allow the tactile perception of the vector, as well as of geometric operations. To standardize the use of the kit, the professors defined specific pieces to represent the origin (Figure 7a) and the extremity (Figure 7b) of vectors hence supporting the concrete experimentation of vector direction and orientation.

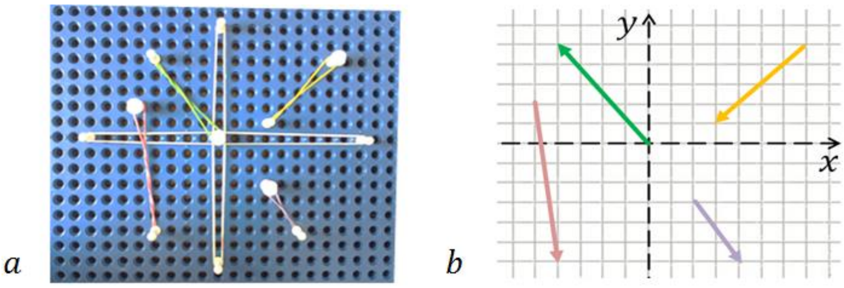
Figure 7 – Tactile simulation of the vector with pieces from multiplane classroom kit.



Source: produced by the authors.

Then rubber bands were used for connecting such pieces and, this way, providing the tactile perception of vector module (Figure c). Prior to use by the blind student, a monitor prepared the multiplane (Figure 8a) representing the cases under analysis (Figure 8b). It can be seen in Figure 8 that the axes of orthogonal basis were represented by a double line, to differentiate such axes from vectors.

Figure 8 – Usage of multiplane classroom kit for tactile perception of cases under analysis.




Source: produced by the authors.

It can be seen in Figure 8 that the axes of orthogonal basis were represented by a double line, to differentiate such axes from vectors. As a result from usage of multiplane kit in the classroom, the student reported ease of handling and satisfactory understanding the cases under analysis (Figure 9).

Figure 9 – Usage of multiplane classroom kit in the classroom by the visually impaired student.

Source: produced by the authors.

## 3 FINAL CONSIDERATIONS

Traditionally, the classes of Analytical Geometry rely on visual resources, such as graphical representations and geometric methods developed in the Cartesian plane. This approach is widely used and commonly provides good student achievement. However, the traditional methodologies may not be adequate in cases of visual impairment, demanding alternative approaches.

From the outcomes reported in this paper, it can be concluded that the usage of touch-and-go by means of the tactile resources built by professors, as well as using the commercial multiplane classroom kit, represents a promising approach as a learning strategy in cases of visual impairment.

According the visually impaired student, there was ease of handling tactile resources, considerable gain in understanding the theoretical subjects and of cases analyzed in classroom. In the perception of professor, the concrete experimentation by using the touch-and-go strategy provided satisfactory support for approaching the course contents of Linear Algebra and Analytic Geometry. Therefore, the authors recommend the use of this approach for similar cases.

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