Learning from the construction of a fidget spinner in a geometry classroom project

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Abstract. Knowledge development is a challenge for Faculty members. Understanding the classroom and societal dynamics allow to think other ways to learn. The fidget spinner is becoming popular among students. That is why in a geometry class from Universidad Pontificia Bolivariana (UPB), the final project was to construct this artefact. During the activity, abilities to design were strengthen as well as to build from scratch the spinner. Students comprehend how it works but also can create new alternatives to improve the spinner cycle. Concepts became clear and the function of geometry take a better relevance for student’s life.

1. Introduction
During first undergraduate levels of any area of knowledge, it is common the need to address the concepts taught by the teacher, it helps to the professional contexts in which students will play once their university education is completed. Geometry and Trigonometry course is not an exception. For Engineering careers in general, education demands a great contribution in terms of applications, that is why here is proposed a classroom project that seek to bring the student to more practical ideas related with the subject contents. An example for Euclidean Geometry could be figures of an entire dimension that allows us to describe and create approximations of nature objects or human creation [1] [2]. Understanding these concepts, often turn out to be abstractions and the time intensity for the teacher mediation can be counterproductive for the relevance that wants to be granted. In order to achieve a better result, the use of a specialized Software has been proposed as an excellent ally to complement the accompaniment provided by the teacher. For this part, not only the use of a specific program such as GeoGebra is achieved, but also, it is possible to give a first approach of the Software that students will cover in their professional careers such as SolidWorks and AutoCAD.

The continuous advancement of technological tools, for example increasing specialized software and easy access allow to energize the curriculum in terms of self-knowledge and skills that are derived from the use of digital resources. After all, new technologies will end up eroding the curriculum and...
demanding adaptation and improvements, intimately articulated to these technologies [3]. This technological path of seeking to improve education does not imply leaving behind the use of traditional teaching tools that have provided significant learning [4]. It is important to recognize that the above demands Faculty a continuous reflection on their pedagogical work articulating the ICT and the student understanding of the concepts that are socialized in the classroom. That is because there may be shortcomings at the level of technological development, which show errors in the procedural part adjusted to an interpretation of low foundation. In general, this type of activity is evident at the moment of making a didactic transposition, understood as the process by which the action of transposing a knowledge towards a didactic site takes place [5] and not as an analogy of what is desired understand. These actions within the classroom adapt mathematical knowledge to transform it into knowledge to be taught [6], that is, transforming an acquired mathematical knowledge and bring it to an adaptation through technological means through a didactic intervention aware of limiting as much as possible the formation of wrong concepts [7]. The importance of generating a lasting knowledge is evidenced when new information is related to some aspect of what already exists in the cognitive structure of the individual, and thus a process that leads to significant learning is produced [8]. Understanding the different variables that affect a case study, allows to create spaces for analysis, discussion and interpretation that lead to real and significant concrete knowledge for those who handle it. Although equations have traditionally been used as recipe for problem solving, they provide a deeper insight when are used as a guide to think [9].

2. Methodologic project guide
Geometry and Trigonometry subject is oriented in the first academic semester of the engineering cycle at the Universidad Pontificia Bolivariana (UPB). A fidget spinner creation has been assigned as the Final Project of the classroom. Fidget spinners are increasing in popularity and, the use of it as a strategy to learn is emerging. The mechanism behind spinners is relatively simple. As any spinning apparatus, fidget spinners rotate around central axis, formed by two rings. By using a ball bearing mechanism instead of simple sliding between the rings, friction may be reduced significantly during rotation. In order to further increase the duration of the rotation, fidget spinners are equipped with three wings (for most spinners) bearing weight distributed equally from the center. [10] This type of artifact also has an impact on the level of improvements in the levels of attention and performance in people with some physical disorders. Fidget spinners are advertised to increase concentration and attention to academic tasks. Past research suggests that hyperactive movements, such as fidgeting, improve performance on attention tasks in children with attention-deficit / hyperactivity disorder (ADHD) [11]. Although also due to the great acceptance of this artifact, many of the students have used it more as a distractor, given the overwhelming interest, countless students started taking their fidget spinners to classrooms, prompting US and UK teachers to ban the toy in schools [12]. However, it is a commitment of the teacher, take those distractions from the environment and mold them in such a way that they can be used in the classroom, that is, teacher can use the toy as an ideal way to present some fundamental concepts of physics [13].

Through topics worked in the class, such as geometric properties of polygons and circles, area, perimeter and volume, students will create a prototype spinner fidget by using a software, starting from an equilateral triangle. In order to generate a document that relates the objectives, the competences to be evaluated and the construction parameters, a methodological guide has been socialized to delimit the activity scope.

2.1. Location
The present project was developed with students of the Universidad Pontificia Bolivariana who are studying the subject of Geometry and Trigonometry. For the same development, looking for transversally in each subject of the basic cycle, student must present basic knowledge of angles, triangles, circular movement, circles and the use of GeoGebra software, SolidWorks or other dynamic software.
2.2. Objectives
   a) Analyze and argue the geometric characteristics of a spinner construction.
   b) Contextualize concepts learned in Geometry and Trigonometry engineering subject.
   c) Design and construct, through a geometric analysis, step by step of a spinner.

2.3. Justification
   a) Students, through mathematical and geometrical concepts, will analyze the different characteristics of a spinner in terms of triangles, circles, arcs of circumference, area, perimeter and angular velocity.

2.4. Cognitive skills
   a) Understand analysis parameters and geometry argumentation to give an explanation of the construction of an object.
   b) Analyze the geometric structure necessary for the construction of a spinner.
   c) Derive necessary formulas for the construction of a spinner using geometry as a tool.

2.5. Communicative competencies
   a) Communicate your project in a fluid and coherent manner.
   b) Prepares a report with coherence and cohesion, which reflects research results carried out on the project.

2.6. Procedural skills
   a) Investigate seriously and give results as stipulated.
   b) Analyze which are the most suitable design conditions for the object construction.
   c) Understand the phenomenon behavior according to environmental variability.

2.7. Attitudinal competencies
   a) Assess other members’ points of view to teamwork.
   b) Promotes teamwork.
   c) It is consistent with the Bolivarian principles and values of the Pontifical Bolivarian University.

3. Construction method
   A triangle of side $l$ proportional to the measurement of the circumference of the bearing is proposed. This triangle must be equilateral (see Figure 1(a)). Then the mediatrices of the triangle are located with respect to each vertex (see Figure 1(b)), The point of the center is the equilibrium point of the figure, this will be the center of the bearing, then the bisectors of the triangle are located with respect to each vertex (see Figure 1(c)) where the center point is the equilibrium point of the figure, this will be the center of the bearing.

![Figure 1](https://example.com/figure1.png)

**Figure 1.** (a) Equilateral triangle, (1) mediatrix and (c) breakeven. Images made with Geogebra.
Next, a circle is drawn from the center previously found and with a radius that is half of the measurement of the diameter of the bearing (see Figure 2(a)). There are cut points of the perpendicular bisector with the side of the triangle and the circumference. The cut point on the side of the triangle is the center and the cut point with the circumference is the radius of the circumference that will form a crown with the circle previously inscribed (see Figure 2(b)). Finding the cut points of the perpendicular bisector with respect to the circumference and taking as center the upper vertex, two circles are made in the upper part of the triangle (see Figure 2(c)).

By axial symmetry, circles previously made are copied, which represent the ends of the spinner (see Figure 3(a)). Likewise by axial symmetry the circles inscribed in the center of equilibrium of the triangle are copied which will help to form the arcs that give shape to the spinner (see Figure 3(b)). With cut points between circumferences and the perpendicular bisector, three-point arcs are formed on each side of the spinner (see Figure 3(c)).

Finally, to design details, objects that are not necessary are hidden to better appreciate the spinner design.

4. Results and discussion
After design making and spinner construction, it was found that weight is a factor that changes the way it rotates. The stability depends on the proper distribution of weight in each of its spinners. On the other hand, the center of gravity should always be in the center circle to avoid sideways movements. The materials of the construction can vary, according to the possibilities of obtaining them. In the class classroom activity, the spinners rotated on average 3 minutes. Figure 4 shows the two spinners that had the most time in rotation.
5. Conclusion
From the activity it was possible to observe the use of the different topics worked in Geometry class regarding the construction of the spinner. The students argued that the rotation time depends on the material used and the weight at the ends of the spinner, since it can affect its angular velocity. The laser machine generated a margin of error in the measurement of the bearing, therefore the space between the bearings and the spinner mold had to be filled.

Due to the use of Euclidean Geometry, students were able to come up with different designs, opening the experience to the achievement of different prototypes that managed to develop creativity and change the conception of what the mathematical and technological methodology provides them. In addition, the construction itself allowed to address the analysis of physical characteristics that optimized or worsened the functionality of the Spinner, as was the incidence of the weight of the ends in the angular velocity, as well as the accuracy in cutting the main body, which would allow to balance its weight in each of its parts and thus achieve a stable turn and, therefore, more sustained.

References
[1] Mandelbrot B and Wallis J 1969 Wat. Res. Res. 5 321-340
[2] Mandelbrot B and Wallis J 1969 Wat. Res. Res. 5 967-988
[3] Moreno L 2014 Educación matemática: del signo al pixel (Bucaramanga: Universidad Industrial de Santander)
[4] Andrade H and Gómez L 1997 Tecnología informática en la Escuela (Bucaramanga: Universidad Industrial de Santander)
[5] Cantoral R and Farfán R 2004 Desarrollo conceptual del cálculo (Colombia: Thomson Learning)
[6] Chevallard Y 1985 Rev. Fran. Péd. 76 89-91
[7] D’Amore B 2011 Didáctica de la matemática (Colombia: Cooperativa Editorial Magisterio)
[8] Novak J 2000 Aprendiendo a aprender (Barcelona: Reverté) pp 220-343
[9] Hewitt P 2017 Sci. Teach. 84(3) 14-18
[10] Cohen E, Bravi R, and Minciacchi D 2018 Sci. Rep. 8(1) 3144
[11] Sarver D, Rapport M, Kofler M 2015 J. Abn. Child. Psy. 43 1219–1232
[12] Strauss V 2017 Schools are banning fidget spinners, calling them nuisances and even dangerous Consulted on: https://www.washingtonpost.com/news/answersheet/wp/2017/06/01/schools-are-banning-fidget-spinners-calling-them- nuisances-and-even-dangerous/?noredirect=on
[13] Lindén J 2018 Phys. Educ. 53 023004