

Computational thinking in higher education in the context of STEM education

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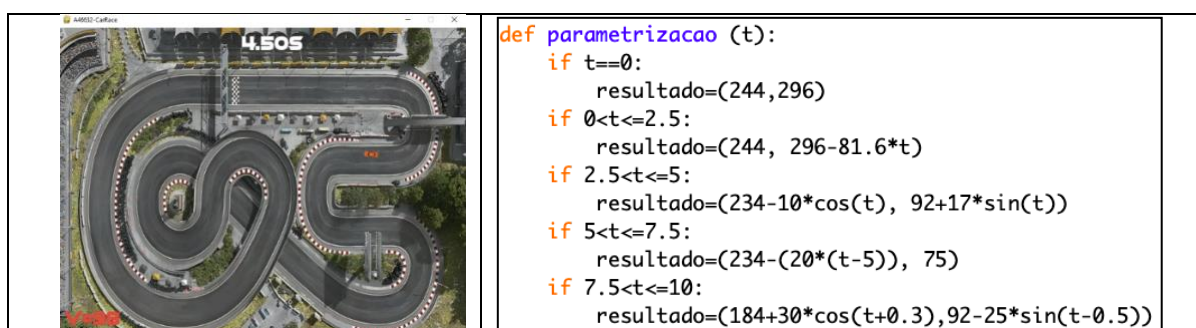
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There is an agreement in the international community about the importance of promoting STEM (Science, Technology, Engineering, and Mathematics) education, not only to motivate students to learn, but also to prepare them to the real-world challenges (Stohlmann, 2018). However, the literature refers to skills shortages in STEM fields and that mathematics contributes to the problem of insufficient STEM graduates (Beswick & Fraser, 2019). Therefore, it is crucial to find approaches to face these issues, namely by highlight the role of Mathematics (Stohlmann, 2018).

In this regard, Computational Thinking (CT) is a cognitive process that can be applied to STEM fields that require problem-solving skills, and also may contribute to help learning mathematics (Li et al. 2020; Lu et al., 2022). In particular, computer engineering students need to have programming skills, namely resorting to mathematics. This poster presents the CarRace project that was implemented in a mathematical class of computer engineering students from the school year 2017/18 to 2021/22. A total of 581 students participated in the project. The aim of the project was to make a car travel along a circuit using mathematics in a Python code. The research question to guide this study is: Does the CarRace project promotes CT in students in the context of STEM education?

To answer the research question, we chose a qualitative methodology with an interpretative approach (Cohen, Lawrence, & Keith, 2007). Data was collected from the projects developed by the students (including a video with the performance of the car in the circuit), and also based on participant observation in class. Figure 1 provides an example of a circuit chosen by a student according to the rules of including lines, parabolas, circles and ellipses, and also the code to make the car circulate, where velocities should be adapted according to its format. Table 1 shows the STEM contents included in the project developed by students.



```

def velocidade (t):
    if t==0:
        vel = 0
    if 0<t<=2.5:
        vel = 81.6
    if 2.5<t<=5:
        distancia = (posicaooy(t)-posicaooy(t-0.1))/(posicaox(t)-posicaox(t-0.1))
        if distancia < 0:
            distancia = -distancia
        vel = distancia/0.1
    if 5<t<=7.5:
        vel= 20
    if 7.5<t<=10:
        distancia = (posicaooy(t)-posicaooy(t-0.1))/(posicaox(t)-posicaox(t-0.1))
        if distancia < 0:
            distancia = -distancia
        vel = distancia/0.1

```

Figure 1: Example of circuit chosen by a student and the Python code

Table 1: STEM contents included in the CarRace project

Science	Technology	Engineering	Mathematics
Physics: velocity, path	Computer Python Calculator Video	Designing Programming	Functions from \mathbb{R} to \mathbb{R}^2 , parametrizations in \mathbb{R}^2 , adjustment of parameters, Linear, quadratic and trigonometric functions Lines, parabolas, circumferences, ellipses Polar coordinates, derivatives, norm of a vector

Based on the reports presented by students, and on participant observation, it is concluded that the project promoted CT in students in the context of STEM education (Figure 1 and Table 1) because it required problem-solving skills and also it helped to learn mathematics (Li et al. 2020; Lu et al., 2022). Indeed, students used mathematics in a programming and STEM context, and developed CT such as abstraction, decomposition, pattern identification, algorithmic and debugging to accomplish the requested tasks. In particular, several mathematical contents were used such as: Functions from \mathbb{R} to \mathbb{R}^2 (parametrizations), including linear, quadratic and trigonometric functions; polar coordinates; curves such as lines, parabolas, circles and ellipses; derivatives and norm of a vector, among others (Figure 1 and Table 1), which made them understand the importance of mathematics in programming and to solve real-world problems.

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