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HYBRID LABS ON TRANSDISCIPLINARITY: KNOWLEDGE THROUGH EXPERIENCE

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BEST PRACTICES BOOK (IO4) AND
CONFERENCE PROCEEDINGS

HYBRID LABS ON TRANSDISCIPLINARITY: KNOWLEDGE THROUGH EXPERIENCE

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A. EXTENDED ABSTRACTS

A01.

An educational approach to Computational Thinking through Arts and Creativity

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The popularization of digital and electronic devices in recent years is producing technological and social changes. In current curricula, whether formal or informal education, it is becoming common to read *Computational Thinking* as a teaching subject. The approach in the high school is potentially interesting beyond its usefulness to get a future job. Organizations such as UNESCO or the European Commission have considered this skill essential for citizens [1]. However, teaching computational thinking is likely to be approached merely as *teaching how to program computers*, losing the opportunity to experiment with its broad scientific and cultural substrate.

Creative coding is a form of computer programming whose purpose is to build something expressive beyond its functional utility. Through creative coding it is intended to address the introduction to computational thinking as a way of personal and artistic expression that is inherently linked to problem-solving skills, communication, and the development of tenacity, based mainly on discovery, experimentation with digital technologies, the exchange of experiences and inspired by various artistic and historical sources. Thanks to the versatile nature of creative coding, an integrated multidisciplinary STEAM training is possible, in which students learn to manipulate digital media in an expressive way and to acquire fluency in arts, sciences and information technologies, so that they discover a likely new approach in which "computer science is not a tool; it is a new material for expression" (MAEDA, 2004).

As an educational tool, learning creative programming matches Papert's conception of Computational Thinking (PAPERT, 1980), which defends the premise that knowing how computers reason can potentially contribute to the formation of mental processes that could ultimately even influence in the way of acquiring new knowledge, developing new ideas and generating self-confidence as rational beings, which carries a significant educational value. In addition, Wing's conception of Computational Thinking (WING, 2006) underlines the desirability of integrating computational objectives into the standard practice of traditional education, thus providing the context for the introduction of creative programming in the classroom as a way of transmitting computational thinking to students, arousing their curiosity, and building personal works based on their own exploration.

The intersection between art and code through the creation of digital elements with the computer provides the opportunity to exercise multiple areas: technical, critical, imaginative, ethical, empathic, etc. with a result usually abstract, creative, inspiring, in short, an aesthetic experience. Based on this, four pathways to approach the learning of computational thinking through creative programming are presented below, along with some pedagogical and didactic indications for their implementation.

Considering that the intellectual stimulation of students is crucial in their performance, in each of the proposed pathways the factors involved in motivation are reinforced [PINK]:

- Purpose: to find in the tasks an important, global cause, an aspiration.
- Autonomy: having freedom, decision-making capacity and participation.
- Mastery: experience improvement, achieve goals, increase skill.

Furthermore, during the sessions, it is worth paying attention that the process serves as a source of learning for the students as much as the final results, so the educational emphasis must always remain on the learning experience, fostering a growth mindset in which error is not permanent and in which learning produces fun and rewards. It is carried out through technical practices (the coding of artistic artifacts in itself) and creative practices (decision making), as well as ethical practices (giving credit to sources, assessing the impact and message of a work) and critical thinking (observing and studying works of art, to understand them and valuing the responsibility that comes with manipulating the digital world). Students will benefit from the incremental nature of programming: the user immediately perceives the consequences of an operation and can isolate, debug, modify it; similar to other artistic processes, such as painters applying a little paint and then stepping back to look at the resulting picture. It is reinforced that students, who usually give more importance to their grades than to their learning, become aware of what they are learning. This will presumably enhance their stimulation, with the positive influence of feedback from the teacher and their own classmates (NEEDLES, 2020). Concrete strategies for the teacher in implementing their educational programming with creative programming could include:

- Context and history of the discipline, the motivations and achievements of the pioneers.
- Reflection on the social and humanistic implications of the topics addressed.
- Publication of portfolios or personal diaries that reflect the progress of the students.
- Strengthening of group and community relations.
- Promotion of healthy competition between colleagues, common repositories, contests, voting, etc.
- Search for inspiration in various sources: artists, geniuses, referents, pioneers, current events, personal hobbies, controversial topics, abstract and subjective concepts, etc.
- Application of the 4 P's (RESNICK, 2017): *projects, pairs, passion, play.*

These pathways aim to promote creative stimulation. They respond to possible triggers of the creative process, inspired by combinational, exploratory and transformational forms of creativity (BODEN, 1987). The work methodology is based on learning by doing, that is, progression through short projects, and the play with art method (MUNARI, 1977) applying the fundamental principles of active pedagogy, proposing that students do by themselves, seek discover, experiment to make room for creativity to flourish. Each path begins by presenting a context and then engages students in questioning, thinking, and writing code. Students are encouraged to share their creations, to help each other and apply Feynman's theory of learning by explaining their solutions to the rest of the class. It is up to the teacher to use some practices such as deliberately showing the process of creating and debugging code, the composition of pencil sketches before coding, pair programming or open discussions, as well as choosing the programming language and environment.

Creative path through the production of analogies

The inspiration comes from imitating works that can be replicated computationally, extracting some quality in the original piece related to its identity and trying to take it to the algorithmic field.

Computational thinking skills include knowing basic commands and flows, creating fundamental shapes, possibly knowing how to apply color, coordinate systems, and introducing loops and elements of randomness when composing images or sounds.

This approach introduces students to the artworks and artists that have been inspiring for computational art and generative art, even encouraging them to dig deeper and discover more details for themselves.

- References: Frieder Nake, Paul Klee, Andy Warhol lithographs, Mondrian, etc.
- Discussion ideas: Michael Noll's experiment "Human or machine" (NOLL, 1966), art from the text-to-image models that generate images from text.

Creative path through exploration

The composition of the artistic artifact starts from simple forms, repeating patterns, modifying parameters. It aims to encourage experimentation and autonomous discovery by students. In addition to concepts related to computational thinking, aesthetic aspects such as symmetry, rhythm, scale, colour, shape control, and the balance between organic shapes and geometric shapes come into play.

- References: The geometric mosaics of the Arab and Mudejar culture, tesserae, textile patterns, musical bases. Artists like Sébastien Truchet, George Ness, Vera Molnar, Kazimir Malevich, who bring students closer to generative art.
- Discussion ideas: Authorship of the artistic work when the computer intervenes. Who is the legal artist of a work of art? Is the creator of an algorithm responsible for the actions carried out by the machine? What problems and ethical dilemmas can it cause?

Creative path through mathematics

Mathematics has often been a dominant theme in the artistic realm of computing. Geometry, curves, fractals or cellular automata can be programmed and serve as a source of creative inspiration.

- References: polygon rotations, Lissajous curves, trigonometric functions, gradients, or simple algorithms, such as the Sierpinski triangle.
- Discussion ideas: Mathematics in everyday life, in nature, in technology. Chaos theory and cellular automata also offer a wide field of debate and research with playful stimulation, for example the game of life (CONWAY, 1970).

Creative path through interaction

Interactive art makes its appearance in the avant-gardes of the early twentieth century. Works appear that require the interaction of the viewer, who ceases to be a mere observer to relate to the work.

Initially, we have the interaction that the user can provide with mouse and keyboard. The response to these events can configure different outputs on the construction site.

- References: from the variety of human-computer interfaces to performance and Op-Art, which plays with optical illusions and a spectator who actively participates by moving in front of the work.
- Discussion ideas: The Fluxus movement, current interactive art, urban interventions, video games and other interactive representations. What characteristics must a work have to be considered art? Should you be persistent? An interactive work is not persistent…or is it?

Adequate attention to diversity finds an ally in the multidisciplinary nature of the proposal. People with different skill sets are equally valuable, they can collaborate with each other, take on the role of mentor and mentee, take challenges further or create teaching material. The *low floor, high ceiling* (PAPERT,2017) approach sets the tone: all students, including the most struggling students, should find it easy to get started; while more advanced students should find no limitations. This concept can be extended with the inspiring *wide walls* metaphor (RESNICK, 2017), which refers to students being more engaged when working on projects that are personally meaningful to them.

Creative programming is a discipline that emerged organically, due to an artistic curiosity that made its way into a mathematical and engineering environment. Bringing creative programming to a classroom of young students, adolescents, restless, connected, digitalized, and at a stage when they make important decisions and question their opinions about the world, seems like a promising task. Teachers and students will discover that they can create artistic pieces of their own in relatively simple and complex ways through creative programming, and this process constitutes a learning experience in itself, with the reward of obtaining tangible results, which subtly reinforce the self-esteem and spirit of achievement.

To finalize our discussion, it is important to emphasize that in such overall educational framework, the ASTER research project is promoting STEAM vocations, with a special focus on Arts made by using digital applications.

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