

What we talk about when we talk about programs

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ABSTRACT

Programming plays a paramount role in many educational policies and initiatives. However, the current focus on coding skills poses a risk of giving pupils an over simplistic and impoverished idea of what programming means and involves. Their experiences would be much more significant if learning were aimed at understanding the richness of the nature of programs.

In fact, programs are strange creatures that escape simple definitions. They are real, in that they affect our real lives; they are abstract, in that they process abstract entities; and they are concrete, in that they take up space in digital devices memory, and can be copied, transferred, corrupted. Thus, understanding the multifaceted nature of programs is crucial knowledge for all citizens of the digital era, and a fundamental component of such an understanding is getting a sense of how programs are created and work (i.e., the programming process).

To the best of our knowledge, there is no Nature of Programs framework (e.g., a set of statements that describe what the nature of programs is), that teachers and policy makers can use to shape their practice and targets. The goal of the WG is developing such a framework, by collecting and organizing contributions from CER, CS experts, and educators.

Work plan:

- analysis of literature (including textbooks);
- identification of the fundamental tenets of the Nature of Programs;
- collection of feedback from the CSE community through surveys or other appropriate research instruments;
- revision according to feedback.

BACKGROUND AND RELATED WORK

The focus on programs. Computer programs are part of our daily life, we use them, we provide them with data, they support our decisions, they help us remember, they control machines, etc. Programs are made by people, but in most cases we are not their authors, so we have to decide if we can trust them. Programs enable computers and computer-controlled machines to behave in a large variety of ways. They bring the intrinsic power of computers to life. Programs have a variety of properties that all citizens must be aware of; due to the intangible nature of programs, most of these properties are

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unusual and peculiar, but fundamental for understanding the digital world. In other terms, understanding the Nature of Programs (NoP) is a key component of the computing literacy: it is crucial to enable a creative and conscious use of computing devices, and should be one of the main outcomes of computing education – alongside with, e.g., the development of problem solving and computational thinking skills. Moreover it should be part of any effort aimed at bringing digital competences to the general public. An attempt in this direction has been carried out by the WG proponents in the occasion of the revision of DigComp 2.1 framework [3]; the outcome of this work is a preliminary list of knowledge statements and examples about the nature of programs¹, as reported in [2].

However, the full understanding of NoP might not be a natural learning outcome of CS activities. For instance, using visual programming environments does not imply that students are able to recognize that the programs they write have the same nature of the “apps” they use on their mobile phones. Similarly, unplugged activities aimed at developing computational thinking skills might be perceived as disconnected from the use of digital devices and programs in everyday life [9, 13]. To overcome these limited perspectives, teachers need to be aware of what NoP is, and use this knowledge to inform their teaching practice.

Programs, programming, and computational thinking. The centrality of programming in CS is reflected in most computing education initiatives², which indeed often include some type of programming activity, mainly under the term ‘coding’. One can even argue that, for many teachers, computer science is just a synonym for coding [16].

Another fundamental component of computing education revolves around the *Computational Thinking* (CT) idea [18]. Even if there is no ultimate definition for it, this idea concerns the ability to address “problems in a way that enables us to use a computer and other tools to help solve them” [7]. This encompasses a variety of creative cognitive processes and activities, like modeling real-life situations, representing information in digital form, organizing data, analyzing and generalizing computational solutions, assessing their social impact, and so on. In other terms, CT goes far beyond coding and tries to represent and value the greater richness of computing.

Since the above mentioned activities play a fundamental role also in the process of designing programs, our WG approach shares a similar scope as CT. A fundamental difference is that CT-based frameworks mostly focus on CT practical and cognitive *skills*, while here we chose to reflect about the underlying *knowledge* about the nature of programs, that CT activities should both promote and stem from.

¹See Section “3.4 Programming” in <https://ec.europa.eu/eusurvey/files/b3537dde-9921-4045-8b29-209610af7990/3e97420f-b810-42cf-9ef3-6d2e8e62e16a>.

²See for instance ALL (<https://www.csforall.org/>) and Informatics for All Coalition (<https://www.informaticsforall.org/>).

Historical and philosophical perspective. As one can expect, the nature of programs has had a relevant role in the broader discussion about the Nature of Computer Science. Some very significant contributions on the issue appeared in the '80–90s [4, 12, 17], one of the triggering question being “Is CS a science?”. CS and its impact in society has greatly evolved since; more recent contributions about the nature of CS can be found in [5, 6, 11]; the book [14] provides an articulate presentations of the topic from an historical perspective. Such a discussion, however, has been conducted by and for CS, philosophy, and history matter experts, and has rarely reached a wider audience. Notable exceptions are [1, 5, 15].

Focusing on programs, the ongoing project “PROGRAMme” starts with the premises that the seemingly simple question “What is a computer program?” has no simple answer today³. It thus aims at developing “a coherent analysis and pluralistic understanding of ‘computer program’ and its implications to theory and practice”, by taking a historical and philosophical approach. The project plans to consider the various characterizations of programs that derive from different viewpoints and pertain to different historical phases of the development of the discipline (either in academia or industry).

While considering wonderful sources both “PROGRAMme” and the references mentioned above about the nature of CS, in the current WG proposal we take a different perspective. We don’t aim at analyzing and contrasting the different points of view about the nature of programs; instead we want to identify the fundamental tenets that bring together all different views, to target specifically the educational arena. Our goal is developing a Nature of Program framework that teachers and educational policy makers can make use of to frame CS teaching practice and curricula.

The Nature of Programs and the Nature of Science. The expression “Nature of Programs” draws inspiration from “Nature of Science” (NoS), a similar expression born in the '70s that refers to the fundamental characteristics of science knowledge and scientific inquiry, as derived from how it is produced: a necessary knowledge to make informed decisions with respect to the ever-increasing scientifically-based personal and societal issues [10]. NoS is a significant component of scientific literacy and it is argued that NoS cannot be learned simply by studying science concepts or attending science labs, but it must be addressed explicitly with active reflective practice and discussions among students in their learning contexts [8]. This also implies that teachers should have a “shared accurate view of NoS” and agree that NoS needs to be taught and assessed explicitly [10].

CS education would benefit as well from a similar approach, in order to boost its contribute in creating a CS-literate society that is able to make informed decisions on CS-based issues. This working group proposes a first step in this direction, focusing on the Nature of Programs (including the way that they are created and built), due to the role that programs play in CS and all society.

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³See the project website <https://programme.hypotheses.org>