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Programming: A tool for meaning-making and a transductive link between semiotic systems.

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Programming is an integral part of modern physics and, at the same time, gaining increased interest in modern education. More and more students are being taught programming at schools. In upper secondary schools in Sweden, where, after the first of July 2018 [1], students are required to experience and use programming in both mathematics and technology. This elevation of programming from a specific subject to a semiotic system used within other subjects, is an indication that programming has entered the "common knowledge"-domain, similar to mathematics or reading and writing.

However, little is known on what programming may offer as a semiotic system for meaning-making in physics when used to create interactive visual representations in 2D and 3D. Therefore, in this project, we ask what disciplinary-specific meaning-making gets constructed by students as they engage with programming as a semiotic system [2] in relation to their disciplinary discernment from the created visualizations [3].

The epistemological starting-point is that students may construct a better understanding for how different semiotic systems and resources are used together for meaning-making to explore and explain a particular phenomenon, and that programing may work as a transductive link between different semiotic systems [2].

To investigate students' meaning-making, we have devised a workshop, based on variation theory [4], where upper secondary students use programming in physics to construct models and create visual representations. In the workshop the participants are guided through the creation of a particle system that follows Newton's laws of motion [cf. 5]. This particle system is then used to explore interactions between particles, such as elastic forces, electrostatic forces, gravitational or other forces.

We have collected video and audio data of students working in groups of three, solving different physics problems. The data analysis is still ongoing, using a qualitative method, and preliminary results suggest that students, with no prior programming knowledge, are able to follow the implementation of models of physical phenomena with little to no problem. This suggests that programming may indeed be a powerful semiotic system very useful for meaning-making in physics. Further analysis will focus on what programming per se means for physics meaning-making and how it works in relations to other semiotic systems used in physics.

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