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#11-41 From real-size to model: the life of CROCUS in the student's mind

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EPFL operates the CROCUS reactor for both teaching and research purposes. While research is inherently valuable and motivated across various topics, the educational mission of the laboratory and the team is equally central. Educational activities span all levels, from providing base access and concepts to numerous visitors, to advanced education at the Bachelor's, Master's, and doctoral levels, as well as training for professionals.

CROCUS is a uranium-fueled, light-water moderated, zero power reactor with a maximum power of 100 W. It is as simple as an operational nuclear reactor can be. This apparent simplicity is a major asset: visible and accessible fuel rods, vessel and hydraulic systems, neutron detectors and power monitors, etc. This accessibility aligns with the pedagogical concept of *affordance*: as an object, CROCUS serves as a highly effective tool for supporting understanding. In a *trialogical learning approach*, it provides the necessary materiality that bridges the explanations of the teacher with the students'active learning process. Students can walk around the vessel, touch it, lean over it to see the inside and the fuel positioning, and even, to an extent, "touch"the fuel. There is virtually no distance, as well as no risk, with a negligible dose rate nearby. However, CROCUS still includes many specificities –physical, instrumental, and mechanical –and can be considered a complex system from an educational point of view. Once basic concepts and systems are understood, it requires a deeper effort to comprehend the machine and the underlying physics at an appropriate level. To achieve this, a variety of tools are employed, all centered on *active learning* principles to facilitate accessibility.

The first and most obvious tool is a Monte Carlo model. When performing computations, students (typically at the Master's level) deepen their understanding of the reactor, its design, and its behavior. Although a valuable complement to time spent on CROCUS, computations lack the tangible quality needed to fully grasp its dynamic, inner workings: it provides a static description and non-functional representation. A more in-depth operational understanding involves a different type of experience: all PhD students whose research includes an experimental component in CROCUS complete the reactor operator license. As a consequence, not only do they gain detailed knowledge of the machine and its working, but they also develop an operational understanding. They come to know CROCUS better than anyone for their specific experimental applications, having operated it for and by themselves. However, this learning path is time-intensive.

To address intermediate educational level, and as a complement during hands-on learning courses, another set of tools has been developed, consisting of tangible models. The first one is a detailed 3D-printed model, made with virtually no approximation. Based on the CAD model of CROCUS, which itself is based on original blueprints, this 1/5th replica is highly detailed and visually attractive. However, it is delicate and requires careful handling. Its fragility and limited movability (as well as cost) mean that it is not well-suited for manipulation but rather serves as a demonstration tool. Furthermore, certain "hidden"features of CROCUS, such as the startup source, or water intake and expansions vases, remain as difficult to visualize as in the actual reactor. While it captures the reactor's appearance, this model's affordance is limited by the same restrictions as the actual reactor, without having the same impressive appearance.

For this reason, a second model was constructed from Lego bricks. This Lego model accurately includes all key features with minimal approximations: the appearance and relative scales of each system are preserved. Its size and structure are appropriate for manipulation and exploration: the core can be "unloaded"similarly to the real one, and it can be disassembled without being damaged. It includes movable parts, such as the spillway and absorber rods, and the vessel can be opened to reveal the internals. This is especially helpful for visualizing difficult-to-see elements, such as the startup source and expansion vases openings, which are typically challenging for students to understand.

In this contribution, we present the educational objectives that we aim to cover, the challenges of communicating a system functioning, and the benefits of using CROCUS and its models. Additionally, we discuss results from evaluating the impact of the new Lego model in classroom teaching.

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