# [$I^3$] Imitation, Iteration and Improvisation: Embodied interaction in making and learning

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*I introduce in this paper a new learning and making process that fosters a new ability to make things through the body's direct, iterative engagement with materials, tools, machines and objects. Tested in a variety of educational settings, this method, which I call 'I3' for its three-layer operation of 'Imitation, Iteration and Improvisation', allows learners to develop their sensory experiences to improvise and create on their own. I introduce case studies in order to test $I^3$. I challenge the separation of design and construction often reinforced by the use of digital fabrication. I show that learning to make and learning from making emerge together through a situated and embodied interaction among the learner, the materials, the tools and the object* in-the-making.


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Historically, there has been a separation between mind and body in theories of art, architecture and craft. Writings about these activities, from antiquity to the present, have persistently suggested that everything must be designed and planned in advance before construction. Moreover, mental activities have been considered the highest creative activity, and the hand is still considered the slave or tool to implement what the mind has dictated. This idea has been taken to the extreme since the mid-twentieth century with the introduction of digital fabrication machines, such as laser cutters and 3D printers. These machines have brought many positive changes to architecture and industry such as precision, expediting construction, and facilitating communication among all parties involved in any project. However, this separation between design and construction in digital fabrication usually hinders direct embodied interaction among the designer, the material and the object *in-the-making*. This direct interaction is essential for improvisation and learning in making. Contrary to common belief, learning to make something is not a black box process or tacit knowledge. Like learning any craft, the learner has to get his/her hands dirty and directly interact with the object *in-the-making*. This direct interaction builds the learner's sensory experience

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and spatial reasoning. Spatial reasoning means being able to imagine things in three dimensions with the least information possible. It is essential to touch the material, make judgments, react to changes in the object, and think about how parts come together. Nonetheless, digital fabrication machines that automate parts of the making process are being installed today in educational settings, intended to serve as a creative means of making and learning (Eisenberg & Buechley, 2008). However, there is no learning process to create this direct embodied interaction in making. I argue that these machines in learning settings are rather used as cookie-cutters or wind-up toys; everything is planned in advance with less space for surprises. But actually reacting to surprises is important in learning to make something.

In contrast to Herbert Simon's definition of design as the 'intellectual activity that produces material artifacts and activities' (1996: p. 111), I view making here as an embodied 'situated action' (Suchman, 2006) that responds to circumstances and surprises, uniting both mental actions, such as design, with physical actions such as construction. This situated action creates both material objects, such as spaces and artifacts, and immaterial phenomena, such as light and experience.

So how do we learn to make something? And what do we learn from making? What are the potential roles of computational tools, theories, and practices for understanding, describing, and enriching making and learning?

To challenge the disembodied interaction so often reinforced by the use of digital fabrication technologies in learning settings, I introduce a new learning and making process inspired by craft learning and observations from experiments I have conducted. Tested in a variety of educational settings from middle school to higher education, this process fosters a new ability to make things through the body's direct and iterative engagement with materials, tools, machines and objects. This method is called $I^3$ for its three-layer operation of Imitation, Iteration and Improvisation. $I^3$ brings the learners back to the lost embodied interaction, and allows learners to develop their sensory experiences to improvise and create on their own.

In the following section, I discuss the relationship between making and learning. I discuss the importance of the *morphogenetic* model versus Aristotle's *hylomorphic* model. I posit that both making and learning depend heavily on embodied, situated experience, which comes from both action and perception. Next, I introduce the role of computational tools and digital fabrication machines in the process of making. I explain how the hylomorphic model has led us to use these machines as 'cookie-cutters' that discourage improvisation. Then, as a remedy to the separation of design and construction in making and learning, I introduce a hands-on learning process, $I^3$. I introduce and analyze