

**MachineShop: A Design Environment for Supporting Children's
Construction of Mechanical Reasoning and Spatial Cognition**

by

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Thesis directed by Prof. Michael Eisenberg

The creative impulse in the human species is nowhere more evident than in children. From an early age they draw, paint, mold, paste, and build a dizzying array of physical objects to both establish their place within societal groups and please and amuse themselves. But this activity is also critical to the cognitive development of the child. From the ages of roughly seven to twelve, children are busy learning to reason logically and to organize thoughts coherently. Piaget calls this the concrete operational stage, where the child has learned to use symbols such as language but is unable yet to reason abstractly. In this stage children begin to truly understand how the world works, and to integrate this information into the knowledge stores that they will use for the rest of their lives. This stage is concrete because this knowledge construction occurs through the construction and manipulation of physical objects in the world.

This dissertation describes a computer aided design and manufacturing (CAD/CAM) system called MachineShop that was created to assist middle school-aged children in the design and construction of mechanical automata. By assisting children as they design mechanisms and then leveraging the power of computer controlled fabrication tools, children can create mechanical devices that they are not yet capable of making by more traditional means. Through this process children have been found to acquire enhanced visuospatial reasoning abilities, improved understandings of the nature of machines, and increased levels of confidence.

Dedication

Max Blauvelt guided and mediated my interactions with machines and mechanisms for nearly thirty years and, unbeknownst to either of us, set me on the path that has ultimately led here. This is for you Dad.

Climbin' a rope ladder over the wall,
I can be anything at all,
I know imagination's the only thing that can stop me.

11 Easy Steps, Keith Grimwood and Ezra Idlet

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There would have been nothing to report if it hadn't been for my six wonderful users: Abbie, Calum, Dylan, Frank, Iris, and Sam. You all rock!

Finally, none of this would have been possible without the encouragement provided by my wife, Susan Hendrix. Without her support, this work might never have been started, much less completed. One down, one to go.

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