# Fab I Can Statements

The Fab I Can Statements are a formative assessment tool that measures achievement and the digital fabrication learning experience intended for K-12.

The statements seamlessly connect classroom activities with benchmarked Fab teaching objectives, state and national learning standards, and with broad outcomes for life-long digital fabrication learning.

The Fab I Can Statements reflect core learning areas across digital fabrication technologies including Design, Programming, Electronics, Modeling, Fabrication, and Safety.

| DESIGN | |
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| **Design 1** | I can be responsible for various activities throughout a design process within a group under instructor guidance. |
| **Design 2** | I can participate in design reviews with prepared presentation materials as well as give and receive feedback from peers. |
| **Design 3** | I can initiate design processes to generate multiple solutions to problems I have framed for multiple stakeholders. |

Design is perhaps the most fundamental of all Fab Lab skills to be learned. Therefore it is often the most difficult to master while also being the most personal and for many the most rewarding. The design statements can be generally understood as progressing from novice to advanced skills, however it should be noted that these statements differ in kind as well as degree.

*Why These Design Statements?*

1. **DESIGN.** Being able to work productively within a group is essential to design practice - at all levels. This statement also emphasizes the need for student ownership of parts of the process - e.g., doing research, making sketches, or giving presentations. At this level it is assumed that teachers are guiding students through a predefined design process, e.g. the engineering design process.
2. **DESIGN.** Habitually documenting one's work within a design process is necessary for preparing and delivering successful presentations at key stages. The statement also highlights the importance of giving and receiving constructive oral and written peer feedback.
3. **DESIGN.** Problem framing and 'satisficing' - coming up with multiple 'good enough' solutions is at the core of good design practice. Recognizing that multiple solutions can exist yet that have trade-offs brings sophistication to the final result. Simultaneously, setting one's own schedule and sequencing for problem solving represents advanced thinking in design.

| COMPUTER PROGRAMMING | |
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| **Programming 1** | I understand the basic structure of a simple program and can modify values, variables, or other parameters to alter its output, function, or behavior. |
| **Programming 2** | I can create a program with more than one instruction. |
| **Programming 3** | I can create a program with multiple instructions and branching elements as well as reading / controlling inputs and outputs on a microcontroller board. |

Computation, especially **computational thinking** skills are important for success across academic subjects, such as using computational tools with geometry to model two and three-dimensional objects. Computation requires the application of creative processes when developing **computational artifacts** and to think creatively while using computer software and other technology to add logic and behaviour to objects.

***Why These Computer Programming Statements?***

1. **PROGRAMMING.** Being able to learn the fundamental concepts of programming that can be applied across a variety of digital fabrication projects. This includes modifying code in a visual programming environment - e.g., changing the values of variables to better understand how they impact the system. At this level it is assumed that teachers are guiding students through basic programming tasks.
2. **PROGRAMMING.** Using computational tools to read and understand basic code examples and recombining these examples to work together as an application or program that solves a previously stated problem.
3. **PROGRAMMING.** Understanding the fundamental principles of programming and the workflow / **toolchain**(s) used. Applying this knowledge to develop relatively complex applications and physical computing projects that include both inputs and outputs.

| ELECTRONICS | |
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| **Electronics 1** | I can follow instructions to build a simple electrical circuit using conductive material basic components and power. |
| **Electronics 2** | I can follow a schematic diagram and create a circuit including a microcontroller with electronic components. |
| **Electronics 3** | I can create my own schematic diagrams and use them to build electronic circuits including microcontrollers. |

Electronics, especially in the area of **physical computing** teaches students how to communicate through computers and other components that are responsible for moving and controlling a mechanism or system. Electronics requires knowledge and use of sensors and microcontrollers to translate and process analog data using software as well as using software to control electro-mechanical devices such as motors, servos and other electronic devices.

*Why These Electronics Statements?*

1. **ELECTRONICS.** Learning the fundamental electrical concepts of electronics such as the use of wire, tape, and other conductive materials to power devices such as LEDs, switches, and sensors. This includes building a functioning circuit built on a paper surface instead of a printed circuit board or PCB. At this level it is assumed that teachers are guiding students through basic examples of electrical principles.
2. **ELECTRONICS.** Reading a schematic diagram, which is a graphical representation of an electronic circuit. This includes soldering circuits to power and control LEDs, resistors, capacitors, actuators, etc.
3. **ELECTRONICS.** Designing or modifying existing schematic diagrams for logic based electronic circuits that include microcontrollers, inputs and outputs with little teacher assistance and guidance.

| MODELING | |
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| **Modeling 1** | I can arrange and manipulate simple geometric elements, 2D shapes, and 3D solids using a variety of technologies. |
| **Modeling 2** | I can construct compound shapes and multi-part components ready for physical production using multiple representations. |
| **Modeling 3** | I can define complex systems with parametric relational modeling using generative, algorithmic, or function representation. |

The modeling statements attempt to reflect the constantly changing nature of design software while promoting long-standing operations and terminology where possible. The statements are built around progressively advancing skills associated with progressively difficult-to-master softwares. Exceptions do exist however and it should be noted that modeling softwares are increasingly merging with programming environments as well as with fabrication tools. Furthermore, online browser-based software introduces additional skills such as account management, file sharing, and collaboration.

*Why These Modeling Statements?*

1. **MODELING.** Software types and brands largely constrain what kinds of geometry can be produced and how they can be manipulated. This statement refers to the use of introductory 2D, 3D, raster, and vector based tools. Also highlighted is the rising popularity of browser-based online softwares, particularly as intended for novice users.
2. **MODELING.** This statement emphasizes the context for which these skills are applied: modeling for physical production. E.g., this is in contrast to modeling for animation or rendering creation. *Compound* shapes refers to the use of boolean operations such as joining or subtracting geometry to produce shape complexity. In particular this is necessary for multi-part components that require assembly after their fabrication, e.g., press fit assembly.

3. **MODELING.** This statement covers two topics. The first is what is being modeled: *complex systems*. This refers to electromechanical products typically with sensing and interactive capabilities. The second topic is how is data is being represented. In parametric modeling abstraction is introduced to ease information overload however defining the relationships introduces upfront overhead. Visual programming represents relational abstractions as connected graphs. Together these topics require that modeling skills become deep and broad.

| FABRICATION | |
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| **Fabrication 1** | I can follow instructor guided steps that link a software to a machine to produce a simple physical artifact. |
| **Fabrication 2** | I can develop workflows across four or more of the following: modeling softwares, programming environments, fabrication machines, electronic components, material choices, or assembly operations. |
| **Fabrication 3** | I can make my own applications, machines, or electronic components to solve new problems and to grow my Fab Lab's capacity. |

The fabrication statements are written to reinforce a core tenet of digital fabrication competency which is that one doesn't learn to master a particular machine or software in isolation, but rather that she must learn patterns of actions and thoughts - *workflows* - that link together multiple machines, softwares, materials, and more to produce a physical artifact. The statements convey progressively increasing degrees of student autonomy as well as workflow depth for any given project.

*Why These Fabrication Statements?*

1. **FABRICATION.** Able to follow an instructor's steps for safely operating basic fabrication machines such as a 3D printer, laser cutter, or vinyl cutter to produce a simple physical artifact.
2. **FABRICATION.** Able to plan and execute workflows through design softwares; introductory or block-based programming languages; machines of increasing complexity such as CNC mills and routers; ready-made electronic components; and materials such as composites, metals, and polymers to produce a functional physical artifact.
3. **FABRICATION.** An advanced student will be able to make their own tools to solve problems that existing tools cannot. This can include software applications such as web interfaces or compilers; machines like multi-axis mills or robotic manipulators; and electronic components such as custom PCB's.

| SAFETY | |
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| **Safety 1** | I can safely conduct myself in a Fab Lab and observe operations under instructor guidance. |
| **Safety 2** | I can operate equipment in a Fab Lab following safety protocols. |
| **Safety 3** | I can supervise others in a Fab Lab and ensure safety protocols are being followed. |

The safety statements are an essential guide for individuals to take precaution for their own safety in a lab environment.  There is potential risk when working with lab equipment and materials, making safety a critical part of the experience.  Each school or space introducing digital fabrication and other equipment and hazardous materials, are mandated to have their own safety guidelines and protocols, the statements of safety here, are overarching and to ensure safety protocols are included in student learning.

***Why These Safety Standards?***

1. **SAFETY.** Able to properly conduct myself and follow the guidance of someone responsible for supervising in a space for experimentation and manufacturing
2. **SAFETY.** Able to operate in a space for experimentation and manufacturing by safely following guidelines and rules of operation
3. **SAFETY.** An advanced state of understanding allowing care of self and others contingent with all safety rules and guidelines

Students learn via active participation and have opportunities to explore their own ideas through discourse, debate, and inquiry. Within this frame lies the presupposition that instructors assume a facilitator role while students are in charge of their learning. It is also assumed that the feedback during the design & build process serves as a scaffolding tool that supports and expedites learning. Finally, situated learning aspects involve students in cooperative activities as a part of which they are challenged to use their problem-solving, critical thinking, and kinesthetic abilities. The intent is to assess the students' Fab solution process separately from their academic performance. Classroom instructors can set short and long-term learning goals by:

- Asking yourself what you expect your students to be able to do with Fab tools and resources after one semester, after one year, or after several years
- Choosing specific Fab I Can Statements or customize new ones to establish learning targets for thematic units and lessons.
- Sharing with your students the Fab I Can Statements you are targeting for each day's lesson and show them how those targets relate to the unit goals.
- Encouraging learners to set their own goals and provide the guidance and class time for self-assessment and reflection.
- Setting student learning objectives based on year-end proficiency targets as defined via the Fab I Can Statements educators can choose specific indicators from which to create SMART (Specific, Measurable Achievable, Relevant, Time-Bound) goals.