Fab Lab Curriculum Guide

Midwest Digital Fabrication Partnership
NSF Grant Project #0802388
Fox Valley Technical College, Century College,
and University of Wisconsin-Stout

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Digital Fabrication / Curriculum Integration Plan and Guide

A Joint Project Between

Fox Valley Technical College

Century College

UW-Stout

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WHERE DISCOVERIES BEGIN

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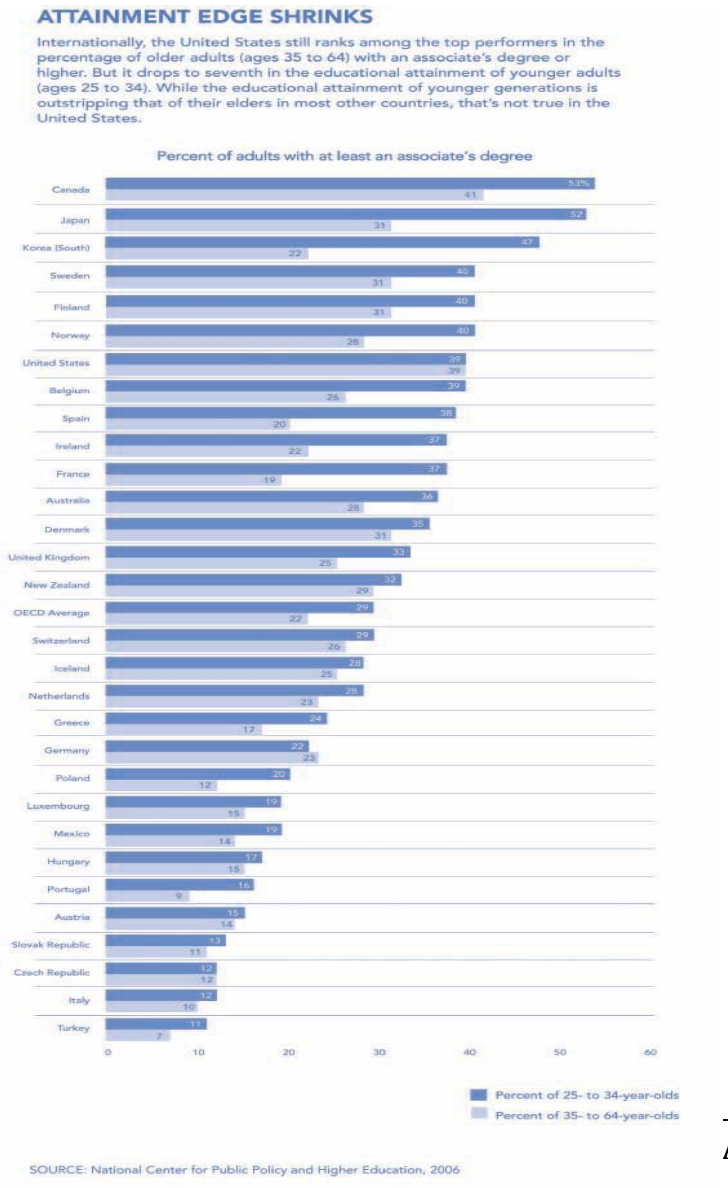
Curriculum Purpose

In the new global economy, states need a workforce with the knowledge and skills to compete. A new workforce of problem solvers, innovators, and inventors who are self-reliant and able to think logically is one of the critical foundations that drive innovative capacity in a state. A key to developing these skills is strengthening science, technology, engineering, and math (STEM) competencies in every student.

Results from the 2003 Third International Mathematics and Science Study, which measures how well students acquired the mathematics and science knowledge they have encountered in school, show that U.S. eighth and 12th graders do not do well by international standards.



We in the United States now live in a world where individual states, as well as the nation, increasingly must generate their own human capital with the STEM illiteracies that will allow them to succeed in the knowledge-based work place and community.

STEM literacy refers to a student's ability to apply his or her understanding of how the world works within and across four interrelated domains.

• *Scientific literacy* is the ability to use scientific knowledge (in physics, chemistry, biological sciences, and earth/space sciences) and processes to understand the natural world but to participate in decisions that affect it (in three main areas — science in life and health, science in Earth and environment, and science in technology).

• *Technological literacy* in the modern world means the ability to use, manage, understand, and assess technology. Students should know how to use new technologies, understand how new technologies are developed, and have skills to analyze how new technologies affect us, our nation, and the world. Technology is the innovation, change, or modification of the natural environment to satisfy perceived human needs and wants.

• *Engineering literacy* is the understanding of how technologies are developed via the engineering design process; lessons are project-based and integrate multiple subjects, making difficult concepts relevant and tangible to students and tapping into students' natural interest in problem-solving. Engineering design is the systematic and creative application of scientific and mathematic principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.

• *Mathematical literacy* means the ability of students to analyze, reason, and communicate ideas effectively as they pose, formulate, solve, and interpret solutions to mathematical problems in a variety of situations. (National Governors Association Report)

Curriculum Overview

Because Digital Fabrication Laboratories are new in the United States and were developed by a research institution, no formal curriculum plans or models exist to help guide educators in leveraging these capabilities in their curriculum. The MDFP project has provided a solution by developing a Digital Fabrication Curriculum Integration Plan and Guide. MDFP partners are applying and validating this model during their own integration of Digital Fabrication Laboratories into their STEM-related courses and programs.

Each partner institution will utilize Worldwide Instructional Design Systems (WIDS) software tools when designing and developing curriculum and instructional materials. This system was developed by Fox Valley Technical College and its Wisconsin Technical College System (WTCS) partners. The Digital Fabrication Curriculum Integration Plan and Guide will be anchored on this competency-based system.

Curriculum Objectives

Science-Technology-Engineering-Mathematics (STEM) programs must demonstrate that their students have:

- An ability to apply knowledge of mathematics, science, technology and engineering to
- Digital Fabrication Laboratory experiences
- An ability to design and conduct experiments, as well as to analyze and interpret data
- An ability to design a system, component, and process to meet desired needs
- An ability to function on inter-disciplinary teams
- An ability to identify, formulate, and solve problems in STEM disciplines
- An understanding of professional and ethical responsibility
- An ability to communicate effectively
- The broad education necessary to understand the impact of STEM in a global and societal context
- An ability to use the techniques, skills, and tools necessary for STEM disciplines

To achieve and then demonstrate these abilities, a list of STEM competencies must be created. These STEM competencies must expand across different institutions including two year and four year colleges. Another consideration would be extending these competencies into the Fab Lab and be appropriate to the lessons and enhancement of those STEM competencies.

The following list of STEM competencies is the result of the collaboration of the partners of this grant.

Competencies

Math

- Students should be able to perform basic Boolean mathematics
- Students should possess the abilities to visualize, compare and transform objects extending 2 and 3 dimensional
- Students should be able to realize a product through the series of logical steps
- Students should be able to use ratios and proportion to produce scale drawings and models
- Students should be able to visualize necessary connectivity in the components of fabricated objects
- Confidence intervals as related to the end user of fabricated products

Science

- Students should be able to read and comprehend scales and other instrumentation to effectively measure properties of fabricated objects
- Students should be able to understand measures of angles and relate them to molecular models
- Students should possess a high level of competency in Physics and the laws of science?
- Student should have a basic understanding of material properties used in fabrication

Engineering

- Students should be able to perform deductive reasoning
- Students should be able to design solutions to engineering problems
- Students should possess basic electrical circuit theory
- Students should comprehend basic mechanics theory

Technology

- Students should be to reverse engineer an object and analyze its components
- Students should be able to perform deductive reasoning
- Student should be able to understand the technological constraints in the realization of an artistic concept
- Students should be able to operate fabrication equipment in a safe and effective manner
- Student should demonstrate appropriate methods of processing, cutting, manipulating, forming, fastening and finishing materials used in fabrication
- Students should be able to sketch designs
- Students should be able to utilize 2-D and 3-D computer aided drafting and computer aided manufacturing software
- Student should be able to demonstrate safe and proper machine set up and configurations

WIDS Hierarchy

WIDS Standards

WIDS provides a consistent framework for quality curriculum design that helps you:

- Specify performance expectations
- Implement valid performance assessment
- Plan learning for all learning environments
- Increase the efficiency and effectiveness of teaching and learning

WIDS Methodology

- Identify learners' goals and performance needs
- Determine intended results
- Connect teaching and learning to the intended results
- Implement targeted performance

WIDS Model

Who are the learners?
What competence do they need to succeed?
How will we know when they're competent?
How will they master the competencies?

Assessments

Each program must have an assessment process with documented results. Evidence must be given that the results are applied to the further development and improvement of the program. The assessment process must demonstrate that the outcomes important to the mission of the institution and the objectives of the program, including those listed above, are being measured. Evidence that may be used includes, but is not limited to the following: student portfolios, including design projects; nationally-named subject content examinations; alumni surveys that document professional accomplishments and career development activities; employer surveys; and placement data of graduates.

The institution must have and enforce policies for the acceptance of transfer students and for the validation of credit courses taken elsewhere. The institution must also have and enforce procedures to assure that all students meet all program requirements.

The following Assessments have been designed by the partnership in an attempt to gauge and measure the enhancement and impact of the Fab Lab on STEM classes. The assessments will be applied and measured from a web based process and administered by the UW Wisconsin-Stout Qualtrics system.

The assessments will track student's experiences by class and project. Each institutions partner will be responsible to assure that the assessments are given and the data is accurate.

Objective	3 Proficient	2 Inter-mediate	1 Beginner	n/a	Score
1. Creativity and Innovation –Students:					
a. apply existing knowledge to generate new ideas, products or processes					
b. use models and simulations to explore systems and issues.					
2. Communication and Collaboration –Students:					
a. interact, collaborate, and with peers, experts, or others employing a variety of digital environments and media.					
b. communicate information and ideas effectively to multiple audiences using a variety of media and formats.					
c. contribute to project teams to produce original works or solve problems					
3. Research and Information Fluency –Students:					
a. plan strategies to guide inquiry					
b. locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.					
c. evaluate and select information sources and digital tools based on appropriateness to specific tasks.					
d. process data and report results.					
4. Critical Thinking, Problem Solving, and Decision Making – Students:					
a. identify and define problems and questions for investigation.					
b. plan and manage activities to develop a solution or complete a project.					
c. collect and analyze data to identify solutions and/or make informed decisions.					
d. use multiple processes and diverse perspectives to explore alternative solutions.					
5. Digital Citizenship –Students:					
a. advocate and practice safe, legal and responsible use of information and technology.					
b. exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity.					
c. demonstrate personal responsibility for learning.					
d. exhibit leadership for digital citizenship.					
6. Technology Operations and Concepts – Students					
a. understand and use technology systems.					
b. select and use applications effectively and productively.					
c. troubleshoot systems and applications					
d. transfer current knowledge to learning new technologies					
				TOTAL SCORE	

Objective	3 Proficient	2 Inter-mediate	1 Beginner	N/A	Score
Mathematics Students demonstrate that they					
Enhance basic Boolean mathematics, Algebra 2/8th grade equivalent					
Possess the abilities to visualize, compare and transform objects extending 2 and 3 dimensional					
Are able to realize a product through a series of logical steps					
Are able to use ratios and proportion to produce scale drawings and models					
Are able to visualize necessary connectivity in the components of fabricated objects					
Science (Biology, Earth Sciences, Physics) Students demonstrate that they					
Are able to read and comprehend scales and other instrumentation to effectively measure properties of fabricated objects					
Are able to understand measures of angles and relate them to molecular models					
Possess a high level of competency in scientific methods (e.g. experiments)					
Have a basic understanding of material properties used in fabrication					
Are able to visualize scientific principles and concepts (e.g. DNA structure)					
Engineering Students demonstrate that they					
Have been able to enhance deductive reasoning					
Are able to perform deductive reasoning					
Are able to design solutions to engineering problems					
Are able to design solutions to fabrication problems					
Possess basic electrical circuit theory					
Comprehend basic mechanics theory					
Are able to use systems thinking and methods					
Are able to visualize 2-D and 3-D systems					
Are be to reverse engineer an object and analyze its components					
Technology (Definition: computer-related and applied technology) Students demonstrate that they					
Understand basic digital computing concepts, principles, and tools					
Are able to leverage networking and connectivity to solve problems					
Are able to understand the sociological technological interface to realize concepts					
Are be able to choose and demonstrate appropriate methods of processing, cutting, manipulating, forming, fastening and finishing materials used in fabrication					
Are able to sketch designs					
Are able to utilize 2-D and 3-D computer aided drafting and computer aided manufacturing software					
Are able to demonstrate safe and proper machine set up and configurations					
				TOTAL SCORE	

Introduction Section

Fab Lab activities can enhance learning experiences in Science, Technology, Engineering and Math (STEM) courses and programs. This evaluation is designed to measure whether the Fab Lab experience has enhanced your science, technology, engineering or mathematics classes.

Section 1

(Demographic Information)

1. **What is your Age?**
   ◯ 17-21 ◯ 22-26 ◯ 27-31 ◯ 32-36 ◯ 37-41 ◯ 42-46 ◯ 47-51 ◯ 52-56

2. **What is your gender?**
   ◯ Male ◯ Female

3. **What is your highest level of education you have achieved?**
   ◯ High School ◯ Associates Degree ◯ Bachelors Degree ◯ Masters Degree

4. **How many semesters of High School Science have you had?**
   ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8

5. **How many semesters of High School Technologies have you had?**
   ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8

6. **How many semesters of High School Engineering have you had?**
   ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8

7. **How many semesters of High School Mathematics have you had?**
   ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8

8. **How many semesters of college level Science have you had?**
   ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8

9. **How many semesters of college level Technologies have you had?**
   ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8

10. **How many semesters of college level Engineering have you had?**
    ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8

11. **How many semesters of college level Mathematics have you had?**
    ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8

Section 2

(Pre Fab Lab Experience STEM attitudinal questions)

1. **What was your interest level in the lesson being instructed?**

◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Very Low	Low	Neither Low or High	High	Very High

2. **What was your interest level in your class?**

◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Very Low	Low	Neither Low or High	High	Very High

3. **What was your interest level in your program?**

◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Very Low	Low	Neither Low or High	High	Very High

4. **You planned on attending a higher education level in your field?**

◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

Section 3

(Fab Lab Experience Questions)

1. **The Fab Lab activity helped you understand the classroom lesson better.**

◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

2. **The Fab Lab activity helped you understand the key concepts of the course better than if you had not had the Fab Lab experience.**

◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

3. **You enjoyed working in the Fab Lab.**

◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

Section 4

(Post Fab Lab Experience STEM attitudinal questions)

1. **The Fab Lab activity increased your interest in the class.**

◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

2. **The Fab Lab activity increased your interest in your program.**

◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

3. **The Fab Lab activity increased your interest in advancing to a higher education level in your field.**

◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

Section 5

(Science, Technology, Engineering and Math (STEM) questions)

1. **The Fab Lab activity increased your level of interest in science.**

◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

2. **The Fab Lab activity increased your level of interest in technology.**

◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

3. **The Fab Lab activity increased your level of interest in engineering.**

◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

4. **The Fab Lab activity increased your level of interest in mathematics.**

◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

5. Tell us what you enjoyed about the Fab Lab.

6. Have you ever had a defining moment in school that made you love or hate science, technology, engineering or math and if so please describe the experience?
