Leveraging the Digital Fabrication Learning Community (DFLC) STEM Learning Model Development

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ABSTRACT
In this paper, we describe the STEM Learning research and model development in an overview of projected findings of the NSF ATE Digital Fabrication Learning Community (DFLC) STEM Learning Project, now in its third year. The foundation for this project was developed by the previous NSF ATE Midwest Digital Fabrication Partnership (MDFP) project.

Categories and Subject Descriptors
K.3.1 [Computers and Education]: Computers Uses in Education

General Terms
Design, Experimentation

Keywords
Digital Fabrication, STEM Technician Development

A final outcome of the MDFP project provided data to support the feasibility of developing a STEM Learning Model for DFLC.

2. RESEARCH SETTING
The projects integrated multiple networks of Educational Fab Labs, Digital Fabrication Experts, STEM Learning Specialists, and Next-Generation Manufacturing (NSF ATE) Centers into an organization that shares all the resources and expertise in a mentoring spirit to establish and grow the pilot Digital Fabrication Learning Community which supports the STEM Learning Model research.

1. INTRODUCTION
The overall goal of the Digital Fabrication Learning Community project is to establish a pilot teaching community to expand the leverage of digital fabrication’s proven enrichment of STEM competencies and attitudes with selected learners and educators while driving next generation manufacturing technician development throughout the USA.

One of the three DFLC’s objectives is to define a DFLC STEM Learning Model and evaluate ongoing impacts of digital fabrication experiences on STEM learners in the pilot Digital Fabrication Learning Community.

The previous MDFP project developed and integrated Digital Fabrication capabilities and resources into learning experiences of students at the undergraduate levels of higher education. INSERT MIT LLK The STEM research questions for that project were:

1. To what extent have the Digital Fabrication Laboratories been integrated into selected courses to provide enhanced, hands-on STEM learning experiences?

2. To what extent have the Digital Fabrication Laboratory experiences increased students’ STEM competencies and attitudes?

3. How effective is Digital Fabrication Laboratories as a STEM recruitment vehicle!
3. METHOD

The MDFP research questions were investigated using content analysis, descriptive analysis, and expert opinion analysis of project records and artifacts. The Applied Research Center of University of Wisconsin-Stout conducted student surveys and instructor surveys over a two-year period. REGS Consulting LLC conducted onsite visits and a virtual visit via PolyCom to FVTC to observe the Fab Lab in action, informally interviewed participants during these visits (n=7), formally interviewed staff (n=2), project leaders (n=5), faculty members (n=3), college students (n=7), school teachers and administrators (n=4), and fourth-grade school students (n=86). One classroom teacher provided student achievement on the units in which the Fab Lab was infused. In addition, REGS Consulting LLC reviewed the project materials available via the PBWorks shared space, reviewed videos of college students discussing their experience and the videos of pre-college students (n=approximately 120) sharing a product they designed, fabricated, and for which they created a marketing plan as part of a fourth-grade unit on entrepreneurship.

The DFLC project is designed to expand the evaluation conducted in the MDFP project and create a DFLC STEM Learning Model to answer the following questions:

1. To what extent do Fab Labs increase students’ STEM competencies and attitudes?
2. What are the critical components of the DFLC Learning Model?
3. How can the DFLC Learning Model be applied to technician development in general?

4. PRELIMINARY DATA AND DISCUSSION

The DFLC is conducting assessments using pre- and post-instruments concerning student learning and attitudes as well as performing case studies with 35 students. A quasi-experimental research design is being applied to isolate the effects of the influences of Fab Labs with regard to students’ STEM competencies and attitudes.

The DFLC STEM evaluator and team have been working with experts from Stanford and MIT, who have functioned in an advisory capacity, to 1) create protocols and instruments to analyze how students in Fab Labs learn to develop and 2) assess the DFLC Learning Model design. Collaboration and information gathering from stakeholders and partners who are engaged in defining the Digital Fabrication STEM Learning Model has been ongoing.

Pilot data using instruments developed as a result of the DFLC

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The college instructors rated the value of the Fab Lab experience to their students highly, also (rating of over 4.0 on scale of 1-low to 5-high):

- Enjoyed the Fab Lab
- It helped to learn in a different way than normally in a regular classroom
- It increased my interest in class and my college program
- It helped to understand the lesson and key concepts of the course better than if they had not had the FAB LAB experience had not occurred
- It increased interest in science, mathematics, engineering and/or technology
- problem-based approach
- experienced work of technicians and professionals
- valuable to the class
- enhanced student learning

The student skills the college instructors rated as being the most enhanced were visualization; understanding fabrication, and designing solutions. The college instructors rated the following 4.0 or higher as areas of enhanced student learning: communication and collaboration, creativity and innovation, technology operations and concepts, critical thinking, problem solving and decision making, and digital citizenry.

Research continues as literature searches and final reviews of external research and internal evaluation data specific to the Digital Fabrication STEM Learning Model are conducted. Ongoing research will more clearly define the target audience and the general perceived end use(s) of the STEM Learning Model, especially in community college settings. Work is proceeding to address the scaffolding for the Digital Fabrication STEM Learning Model and development of a draft model is anticipated by the third quarter of this funding year, which will then be disseminated to the Learning Community for review and comment.

Because the MDFP project was in the National Science Foundation ATE program, the competencies and skills enhanced by the Fab Lab experience were mapped to the following systems:
- the Partnership for 21st Century Skills P21 Framework (www.21stcenturyskills.org),
- the advanced or next generation manufacturing skill sets (www.careeronestop.org/CompetencyModel/pyramid.asp?gh=Y),
- the list of skills and competencies developed in the first year of the MDFP project, and
- the skills mentioned by instructors in interviews and surveys in the following table:

5. CONCLUSION
The DFMC project continues to analyze these areas of criticality, particularly as they relate to a Digital Fabrication STEM Learning Model. Again, very preliminary findings strongly suggest a powerful relationship between these areas and the acquisition of higher order thinking skills and soft skills. The foundational elements appear to be the ability to blend creative thinking with technical thinking to promote high levels of innovation directly associated with next generation manufacturing and technician skills. These factors and others will generate a strong and useful Digital Fabrication STEM Learning Model.

6. REFERENCES