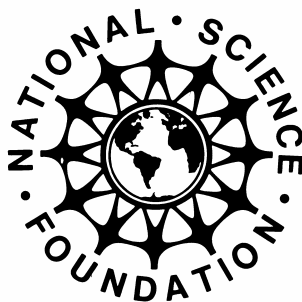


## **Final Report**

### **Rapid Prototyping Laboratory Improvement for Interdepartmental Access and Program Partner Education**

**June 1998- November 2000**

**7400 Undergraduate Instrumentation and Laboratory Improvement  
#DUE 9851314**



**February 2001**

**Submitted by:  
J.C. Malitzke  
Principle Investigator**

## **EXECUTIVE SUMMARY**

NSF-ILI Grant #DUE 9851314 was awarded effective July 1, 1998. Preliminary work had started before that time. Initial meetings for curriculum revisions to the Mechanical Design and Drafting/CAD program began in early 1997. Rapid prototyping was discussed as a critical component missing from the program. Research into previous NSF grants commenced and the College decided to pursue this grant. The initial National Science Foundation briefing meeting, with the principle participants of the College in attendance, was held on July 30, 1997. (See Attachment A) Subsequent meetings were held on a monthly basis to finalize the NSF ILI grant proposal.

The goal of the project was to integrate rapid prototyping into a fully networked CAD/CAM/Engineering environment while fostering shared use of equipment and curriculum collaboration between college departments. Rapid prototyping is the key element in integrating computer technology in the teaching of design to manufacture from the initial concept to final delivery of product. The major objectives to:

- revise curricula in seven courses
- develop a rapid prototyping lab
- provide hands-on learning experiences for high school and college students
- sponsor hands-on learning seminars for high and college instructors

were all accomplished during the time frame of this project. The program outcomes moved student learning from a design step with 3D geometric models to an actual prototype of the part followed by analysis and refinement of the product. Students were engaged in the learning experience in a real-world rapid prototyping environment.

Students from various high schools, colleges, and businesses created rapid prototyping models using the state-of-art technology provided by this grant. Students were able to make more informed design decisions and to synthesize information using this technology. Educating people to synthesize the information gathered based on rapid prototyping choices was the essence of this design project.

During the three years of this project, Moraine Valley Community College has seen a transformation of its Mechanical Design and Drafting/CAD program, from 2D design to the incorporation of 3D design. The use of rapid prototyping has enhanced the program to a level that was not imaginable three years ago. The original goal to revise seven courses was increased, and nine courses were revised. The Mechanical Design and Drafting/CAD program had two major program revisions during the grant period. The College has experienced increased enrollments in the Mechanical Design and Drafting/CAD program, and many high schools, colleges, and local businesses have contacted the college for the further use of and consultation on this technology. Unfortunately, the Automated Manufacturing program, which was also included in and impacted by this project, did not experience the kind of transformation and enrollment increases expected.

## **PARTICIPANTS**

J.C. Malitzke, Professor of Mechanical Design and Drafting/CAD was the Principle Investigator for the grant project. Mr. Malitzke's main responsibilities were to lead all components of the project. Mr. Malitzke coordinated curriculum revisions, videotape creation for recruiting and rapid prototyping usage, marketing activities, purchasing of the rapid prototyping machine, computers, servers and build materials. Mr. Malitzke was also involved with student recruitment and worked with all outside institutions and organizations to enhance this project.

Chuck Bales, Assistant Professor or Mechanical Design and Drafting/CAD, Co-Principle Investigator, assisted in curriculum revisions, created procedures for rapid prototyping machine usage, rapid prototyping modeling projects recruitment, and other project assignments.

Maria Vlamakis, Assistant Professor, Mechanical Design and Drafting/CAD, Co-Principle Investigator, assisted in curriculum revisions, recruitment, and other project assignments. Ms. Vlamakis also worked with the engineering graphics transfer students.

Bob Malis Associate Professor, Automated Manufacturing program, Co-Principle Investigator, worked on curriculum revisions, and was the liaison member to the Automated Manufacturing program of the college. He also team taught MDT 270 CAD/CAM Concepts with Mr. Malitzke, using 3D CAD design to rapid prototyping and ultimately to CAM programming outcomes.

A major contributor to Moraine Valley was Autodesk Inc. Under the auspices of Autodesk Inc. and with assistance of Aidex Corporation, the summer CAD Teacher Training Program was held at Moraine Valley Community College for the summers of 1999 and 2000, and will also be held in the summer of 2001. This program provided hands-on learning using 2D and 3D CAD design software. Over 159 teachers from high schools, 2 and 4-year colleges and universities attended.

Collaborations were an important part of this project. Local high schools requested their 3D designs be produced using Moraine Valley's rapid prototyping machine. J. L. Richards High School in Oak Lawn, IL requested assistance with their Build Your Dream Car Competition designs. In this national annual competition for designing a future dream car under the auspices of Daimler-Chrysler Corporation, Richards High School placed 1<sup>st</sup> in 1998 and 3<sup>rd</sup> in 1999. (See Attachment B) Also, New Trier High School, in Winnetka, IL, worked with the College on producing a rapid prototyping part of their design to create golf putter heads. The College assisted in creating rapid prototyping models for their program. A faculty member from the Illinois Institute of Technology's Architecture program requested part creation for a programming class. These models were used to verify the students' programs. Recently, Argonne National Laboratory has requested collaborative work for creation of design models, and Moraine is negotiating with them for future curriculum revisions and design collaborations. Other companies

have requested part creation to test their 3D designs, and assistance is provided as time permits.

## **ACTIVITIES AND FINDINGS**

### **Rapid Prototyping Laboratory Improvement for Interdepartmental Access and Program Partner Education, (#9851314) 1998-2000 Funds: \$57,584.00.**

The overall project for implementing rapid prototyping content into existing courses has been a huge success for Moraine Valley Community College. The dissemination process to high school students, high school and college instructors, industry professionals and other interested parties has been equally impressive.

The college renovated space for this project at a cost of \$6,000.00. This room is dedicated to the rapid prototyping machine and all printing and plotting for the CAD and CAM programs.

### **Enrollment Patterns**

Credit hour enrollment patterns in the Mechanical Design and Drafting/CAD program have increased during this grant period. Between 1996 and 2000, a 13% increase in fall semester enrollment has occurred. For the spring semesters 1999-2001, the enrollment increased 5%. However, the spring semesters seatcounts averaged 16% *higher* than that of the previous fall semesters.

The Automated Manufacturing program enrollment has not been as positively effected during this time frame. For the fall semesters from 1998 to 1999 the enrollment dropped 35% but remained virtually the same from 1999 to 2000. For the spring semesters, the enrollment from 1998 to 2000 dropped 19%. This enrollment decline is not attributed to this project, and is being addressed by the College.

Engineering transfer students for the fall semesters from 1998 to 2000, the enrollment increased slightly. For the spring semesters the enrollments has been steady for the past two years with a slight increase for the spring of 2001.

Enrollment of female students in the Mechanical Design and Drafting/CAD program has been steady. The fall 1998 female enrollment was 17%, fall 1999 was 19% and the fall 2000 was 20%. The spring enrollment percentage has averaged around 21%.

### **New and Revised Courses**

Two program revisions occurred during the time Moraine Valley operated this NSF project. The first of these resulted in rapid prototyping being incorporated into eight courses, and the second resulted in it being incorporated into a ninth course.

The current rapid prototyping machine is used to provide samples of 3D models designed and redesigned by students. During the first program revision, rapid prototyping as an integral part of the design process was integrated into eight different courses. Five

courses implement design problems into the curriculum, while three courses demonstrate an understanding of rapid prototyping techniques and industry trends. Between 1998 and 2000, the following courses were revised:

- *EGN-150, Engineering Graphics*, Understanding and general information on rapid prototyping. Note: This same information was shared with students in *MTO-101, Introduction to Machine Tools*.
- *MDT-145, Introduction to CAD*, Understanding and general information on rapid prototyping, 2D and 3D part creation and hard copy creation.
- *MDT-160, 3D Modeling and Rendering*, Design and redesign to final part creation. 3D assembly of parts and analysis were incorporated. Rapid prototype parts are created as needed.
- *MDT-270 CAD/CAM Concepts*, Team-taught by the Mechanical Design and Drafting/CAD program and the Automated Manufacturing program. Creates and generates the manufacturing of data files from 3D CAD models. Rapid prototyping parts are created and revised as needed. Data files are sent from CAD program to CAM program.
- *MDT-285, Introduction to Parametric Modeling*, Parametric design and redesign to final part creation. 3D assembly of parts and analysis were incorporated. Rapid prototype parts are created as needed.
- *MTO-230, Process Modeling: SmartCAM*, Design and manufacture process is studied. Generation of manufacturing data files from 3D CAD models and creation of 3D CAM models. New parts are created and rapid prototyping models are created.
  - Note: This course only ran once during the three-year timeframe of this project due to low enrollment. As a result, revisions to this class and to the Automated Manufacturing program are underway and scheduled for completion in fall 2002. New courses in CAM programming and new software's are under study. Rapid prototyping will be an integral part of these new classes and program.
- *MTO-240, Process Modeling: 3D SmartCAM*, Generation of manufacturing data files for 3D CAD models. Rapid prototyping models to be created as needed.
  - Note: This course is also being revised as part of the overall Automated Manufacturing program revision. See Note under MTO-230 above.
- *MTO-129, Survey of CAD/CAM/CIM Methods*, Understanding and general information on rapid prototyping.

The second program revision in the Mechanical Design and Drafting/CAD program occurred during the three-year period of this project will result in new certificates and revisions to the A.A.S. being made available by spring 2001. The following course is new, resulting in nine courses being impacted by this project.

- *MDT-288, Applied Parametric Modeling*, Parametric design and redesign to final part creation. 3D assembly of parts and analysis were incorporated. Rapid prototype parts are created as needed.

### **Student and Faculty Trained/Impacted in this Project**

1. Over 1,500+ college students have been exposed to the rapid prototyping machine technology by either attending one of the eight different departmental courses or by observation of the technology during the three-year timeframe of this project.
2. Under the auspices of Autodesk Inc., Moraine Valley hosted teacher-training courses in 2D and 3D CAD. (See Attachment C) Over 159 high school and college faculty from six states attended technical training workshops on CAD software and on rapid prototyping technology. These classes were held during the summers of 1999 and 2000. (Five Teacher Training courses have been selected and advertised to 800+ design faculty members for summer 2001.) Classes were held in AutoCAD Update, CAD Classroom Management, 3D Modeling and Visualization, Mechanical Desktop, 3D Studio MAX and 3D Studio VIZ. A new class using Autodesk Inventor will be added to this years summer class selection. Rapid prototyping models will be created during the classes that use 3D software.

Faculty received training in:

- Pedagogical classroom delivery methods for CAD
- rapid prototyping awareness or creation of rapid prototyping models
- curriculum materials and software to be used in their classroom

Each faculty member gained insights on this technology by observation, classroom lecture, and hands-on manipulation of 3D CAD software to create STL files for creating rapid prototyping models.

3. During the summer of 2000, a hands-on seminar entitled: “You’re Invited to Learn More About Rapid Prototyping” was advertised to 250+ high school and college instructors. (See Attachment D) This seminar discussed the history of rapid prototyping and current rapid prototyping technology. Videotapes on current rapid prototyping technology were shown, and participants experienced hands-on design and refinement of rapid prototyping models. Each attendee gained a better understanding of rapid prototyping technology and a part that they created during the seminar.
4. Field trips for high schools were conducted every year as requested. High school faculty contacted college faculty to schedule demonstrations of the CAD programs and rapid prototyping. (See Attachment E)
5. Moraine Valley Community College is an Authorized Autodesk Training Center concentrating on training industry professionals using Autodesk software products. During the three-year period of this grant, Moraine Valley’s ATC trained 1600+ industry professionals on CAD based software. The 3D modeling training classes receive a demonstration of rapid prototyping technology.

6. Tech Prep articulation agreement meetings between Moraine Valley Community College and the 10 high schools that comprise the Moraine Area Career System took place in 2000. Faculty and administrators met to discuss procedures that will allow high school students to obtain college credit for taking high school classes that articulate with Moraine Valley's classes. Rapid prototyping technology and the importance of our programs was discussed.
7. Recruitment activities were conducted at local high schools during the grant period. Moraine Valley staff made presentations on the current CAD programs at the following high schools: Victor J. Andrew High School, 25+ students, Argo Community High School, 100+ students, John F. Kennedy High School, 300+ students, Richards High School, 25+ students, Evergreen Park High School, 15+ students, Reavis High School, 25+ students.
8. A Web page (<http://cad.mv.cc.il.us>) was developed for this project, and dissemination of the project via the Web page is ongoing. Planned updates include this Final Project Report, and information on how schools and businesses can gain access to rapid prototyping technology at Moraine Valley. A curriculum sharing and dissemination area will also be included on the Web page.
9. In collaboration with St. Xavier University, a seminar on CAD and rapid prototyping was presented to nine women visiting the campus. They were very interested in the demonstrations and tours, and their questions and survey results indicated that the students would have liked more time at Moraine Valley. They especially liked the hands-on experiences. (See Attachment F)
10. Since the fall of 1998, the college has operated a program in cooperation with the Chicago Public School System entitled: The College Excel Program. This program's mission is to educate Chicago Public High Schools students by enrolling the students in various community college technology classes. The objective of the program is to provide our the students with solid academic, technical, and employment skills. Moraine Valley's Mechanical Design and Drafting/CAD program has enrolled over 100+ students during the last three years. Every year the Mechanical Design and Drafting/CAD program gives a presentation at the College Excel Orientation meeting describing its program and the classes that Chicago Public School system students can attend. The 75-125 attendees are principals, vocational directors and faculty members of various CPS high schools. During each presentation, rapid prototyping is discussed and models are presented for observation. The goal is to recruit to the CPS students into Moraine Valley classes. (See Attachment G)
11. In March of each year, the Illinois Drafting Educators Association holds a regional Drafting/CAD competition. Moraine Valley is a host site for this competition. Students from up to 10 high schools compete in Introduction to Drafting on the

Board, Mechanical drafting on the board, Architecture on the board, Introduction to CAD, Mechanical CAD and Architectural CAD. Student attendance for 1999 was 78, for 2000, 141 and for 2001, 149. During the competition, high school instructors are invited to a demonstration on rapid prototyping and learn how their schools can take advantage of the technology at Moraine Valley. Also, discussions on curriculum projects that take advantage of this technology are included. After the competition, students interested in rapid prototyping technology participate in a tour and a question and answer session. During the past two years, a total of 219 students and 10 different high school instructors participated in this competition. (See Attachment H)

12. During each of the past three years, Mr. Malitzke has attended the Autodesk ATC managers meetings held both at Autodesk and at local locations. These meetings also include discussions about the NSF grant on rapid prototyping.

## **PUBLICATIONS AND PRODUCTS**

A brochure on the use of rapid prototyping technology was created and sent to over 800+ high school and college instructors. This brochure was designed for a one-day seminar entitled: “You’re Invited to Learn More About Rapid Prototyping”. (See Attachment D)

A second marketing brochure entitled : You’re Invited to a Rapid Prototyping Demonstration, was created and sent to the same 800+ high school and college instructors. This piece served as an invitation to bring prospective high school and college classes to Moraine Valley Community College to discuss and have hands-on experiences using our current rapid prototyping technology. The marketing piece will be revised as needed and sent out annually to schools that are interested in this technology. It will also be used as a recruitment piece to local feeder schools. (See Attachment E)

Press releases published in the local newspapers are attached. (See Attachment I)

This project is published in the following Web page (<http://cad.mv.cc.il.us>). The Web site will be updated regularly to disseminate information about ongoing seminars on rapid prototyping technology. The site will also reflect Moraine Valley’s willingness to become a service center for model creation to high schools, colleges, and businesses. Also, the dissemination of 3D CAD curriculum projects and problems and rapid prototyping models will be exchanged in the curriculum sharing area of the Web site.

To promote females entering this traditionally male dominated career, a marketing piece was created by the College’s Marketing and Publications department of the college. This piece depicts females in traditional male dominated work roles and males in traditionally female dominated work roles. Three female students for the Mechanical Design and Drafting/CAD program were featured in this marketing piece.

Course handouts and design problems for 3D CAD model creation were developed, used for instructional purposes and then revised as needed.

Two videotapes were produced as a result of this project.

1. A half-hour videotape was produced about the updates to the CAD program featuring the rapid prototyping machine and its capabilities. The original plan was to produce a distance learning telecast to the Southwest Metropolitan Regional Higher Education Consortium/SMRHEC. However, it was decided instead that a videotape about Rapid Prototyping would be produced and disseminated to all K-12 schools and higher education institutions. Two videotape productions were completed. The first videotape became obsolete within the first few months of production because of all the updates/revision occurring in the CAD program at that time. A second videotape was produced after the new prototype machine was installed and new CAD and new rapid prototyping software was installed. This new tape will be sent to all schools in the Moraine Area Career System and to the SMRHEC colleges. The videotape discusses the following:
  - Current rapid prototyping technologies
  - Hands-on demonstrations on 3D CAD geometry manipulation into the rapid prototyping machine
  - AutoCAD 2000i, Mechanical Desktop and Autodesk Inventor were used to show students and teachers methods to prepare rapid prototyping models
  - Rapid prototyping software manipulation of 3D Sterolithography models using Thermojet Rapid Prototyping software. This manipulation of copying, scaling, nesting, mirroring and rotation of the model was used for proper placement of the 3D model for final build. Once the 3D model was positioned properly, the rapid prototyping machine created the 3D model. Final 3D-model removal from its build platform and cleaning was also shown.
2. A second videotape was produced for recruitment purposes for the Mechanical Design and Drafting/CAD program. The video describes the current program, including rapid prototyping, and shows diversity in the student population.

## **CONTRIBUTIONS**

**To the students:** The contributions from which students benefit includes the new CAD and CAM curriculum that incorporates rapid prototyping. This new curriculum reflects the first major infusion of a new technology at the College in many years. CAD and CAM software have been used for years, but the validation and analysis of 3D models did not exist. With this new tool, both CAD and CAM students can see their designs come to life before they are sent to be manufactured. Redesigns can take place at any time in the design process. Students benefit by using this technology that is not available in most schools. By using Tech Prep articulation agreements between the college and local high schools, high school students should experience a smoother transition to the community college and possibly to a four-year university. With this technology, we redefine the delivery of the instruction, bring our programs up-to-date, and give our students opportunities to be prepared for the current workforce.

**To the faculty:** The contributions to faculty include curriculum revisions that assist the community college high school faculty to not only learning this new technology but also

to implement updates in their curriculum and courses. By adding this new technology into 3D CAD/CAM courses, the faculty can assist students in the validation and analysis of the student's 3D models. New competencies, new tasks, and new design problems will help embrace this technology. The multiple professional development opportunities provided to numerous college and high school faculty disseminated this new curriculum throughout the region.

**For the college and high schools:** The colleges and high schools participating in this project benefit by being able to position themselves to better display and take the lead in teaching modern technology that does not exist in most schools. Moraine Valley has positioned itself as a service bureau for model creation and as a curriculum development site for high schools and colleges that wish to incorporate rapid prototyping technology into their curricula. Moraine Valley is now positioned as a regional leader in 3D CAD technology with rapid prototyping as a core feature. A revised Web page will be the dissemination vehicle for sharing content and ideas. As new technologies develop, participating institutions will serve as catalysts to support improvements in the curricular status quo. Since Moraine Valley was successful with this project, support and involvement from other institutions will be easier to obtain in the future.

The College has already committed to continued implementation beyond the end date of the grant. Because of this continued support, all new 3D CAD or CAM courses will incorporate rapid prototyping technology. This project impacted positively on the program revisions incorporated into the Mechanical Design and Drafting/CAD in 1998 and 2000. In addition, a new certificate in 3D CAD was approved by the state of Illinois for the fall of 2000 semester. Nine courses were either revised or created during the project timeframe.

## **FINAL COMMENTS AND CONTINUATION OF PROJECT**

The college has supplied additional funding to support this grant program for instructional supplies, staff travel, faculty stipends, and the annual machine maintenance contract. These contributions total over \$17,000 during the grant period. In addition, the College provided in-kind contributions for public relations and marketing, recruitment, project administration, and overall moral support.

Due to rapidly changing technology, the 3D Systems, Inc. Actua 2100 Rapid Prototyping machine purchased with grant funds at the beginning of the project became obsolete, and the annual maintenance agreement of \$10,000 was too expensive. The College contacted 3D Systems, Inc., and negotiated an agreement to purchase their new Thermojet machine as an upgrade to the existing Actua 2100. Moraine Valley purchased this upgraded machine for \$25,000.00 and it was installed in January 2001.

Increased enrollment in the Mechanical Design and Drafting/CAD has been a pleasant surprise since overall enrollments at various community colleges tend to be in decline.

This grant provided Moraine Valley Community College with technology that previously did not exist in the Chicagoland area. Revising the curriculum and disseminating this information to high school and college students, faculty, and administrators, and to businesses has increased visibility for the College's rapid prototyping capabilities. There is added excitement in that Moraine Valley is the only one that has the newest technology in the area, and that Moraine Valley is committed to sharing what it has learned with others. Because of the success of this project the college will continue to support rapid prototyping after the grant period has expired. New classes and revisions to existing classes, dissemination to schools and businesses will continue in the future.