AC 2008-930: BROADENING RAPID PROTOTYPING AWARENESS VIA P16 STEM TEACHER WORKSHOPS

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Dr. Tim Dean is an Associate Professor of Electrical Engineering Technology at Nashville State Technical Community College in Cookeville, TN. He has over 13 year experience teaching in the engineering technology field as well as several years experience as a consulting engineer in the field of industrial and manufacturing automation.

Broadening Rapid Prototyping Awareness via P16 STEM Teacher Workshops

Abstract

The Objectives of the NSF CCLI Phase 1 Award 0536509 are to provide exposure to, and dissemination of, state of the art rapid prototyping technology to educational institutions that do not otherwise have access to such technology. These objectives are accomplished through the development of an Internet based remotely accessible rapid prototyping laboratory. As part of the project deliverables, the project team has been conducting P16 STEM teacher workshops for the last two years. This paper will report on the structure of the workshops, survey data collected from the teachers, and practices that have been implemented by instructors and teachers at their host institutions.

Introduction

Project principal investigators have attended various Rapid Prototyping workshops before and reported on the best practices in various publications[1]. As part of NSF CCLI award, two workshops have been organized thus far. In each workshop, ten teachers have been recruited and trained in the use of rapid prototyping technology with emphasis on its use in STEM related disciplines.

In 2006, ten K-12 teachers attended training seminars at the TTU campus rapid prototyping laboratory. The training exercises included the production of rapid prototype models of a Porsche automobile. Follow-up training and laboratory visits have been scheduled for these teachers' students.

In 2007, ten higher education faculty (2 from universities, 8 from community colleges) were trained using the lab's remote access capabilities. Sample part prototype models were produced and mailed directly to the participating faculty. The remote lab has been used during the Fall 2007 semester for course projects, case studies, and student homework assignments.

During the semester, students submitted course exercise assignment model files and project model files to the course instructors. In some cases, the instructors chose the best student submissions for prototyping in the remote laboratory. At the end of the semester, teacher and student feedback was obtained using an IRB approved survey instrument.

This paper will provide an analysis of the teacher and student feedback information.

Recruitment of Participants

Teacher recruitment efforts were handled by the TTU STEM center. Recruitment flyers were prepared and posted through the TTU website. Announcements were also emailed and faxed to regional schools. The emailing of flyers directly to area schools proved to be very informative for teachers and beneficial for faculty recruitment purposes.

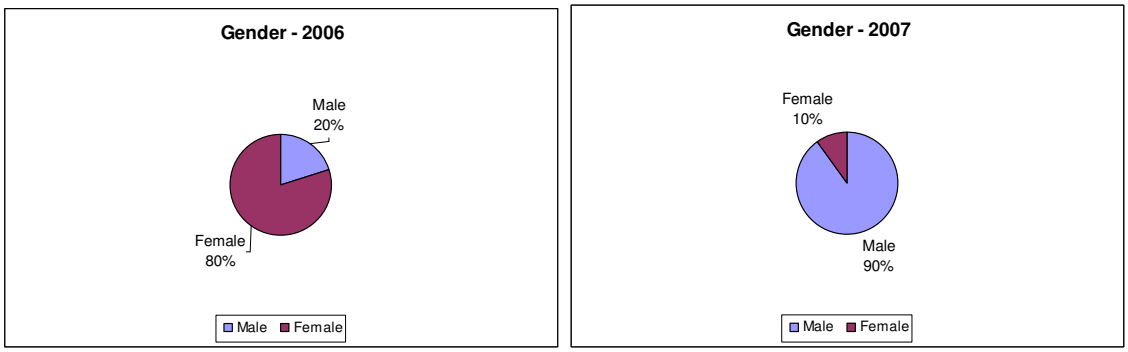
Agenda

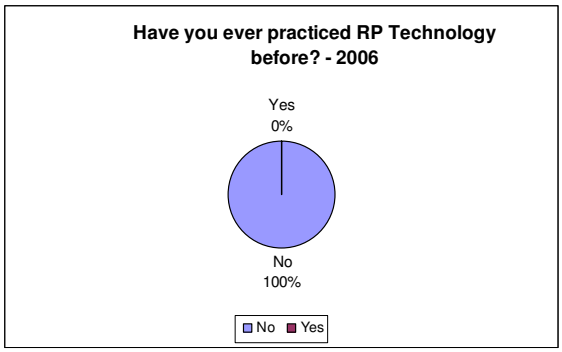
Since most teachers and instructors had little or no knowledge of current rapid prototyping technologies or the TTU rapid prototyping laboratory capabilities, the following categories of information were conveyed to participants.

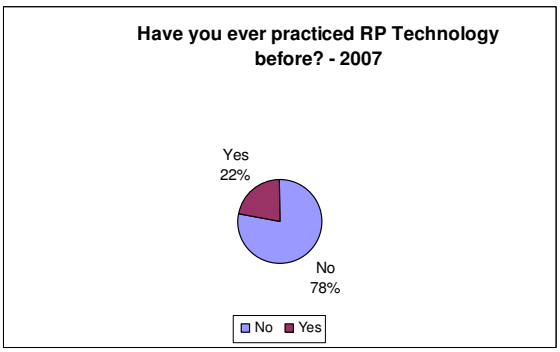
- What is RP?
- How does it work?
- What are the differences in the Remote Rapid Prototyping Laboratory?
- Ways to communicate?
- How to follow-up?
- Future Work

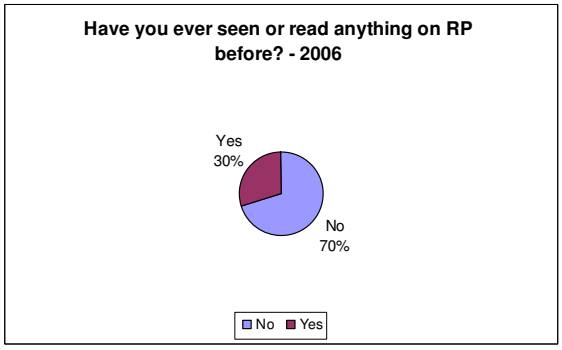
All teacher and instructor participants received website information, communication and scheduling mechanisms, and sample rapid prototyped materials. The participants were requested to complete a survey instrument for the purpose of obtaining feedback relative to their previous experience with rapid prototyping technology.

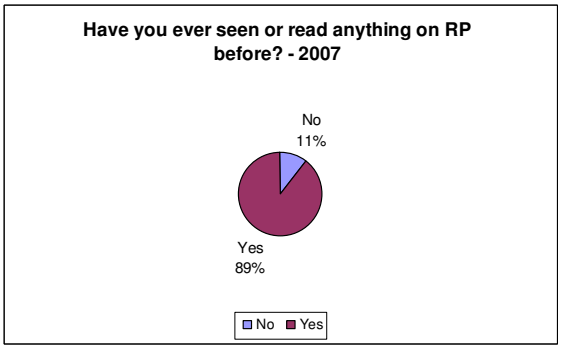
Figure 1 presents highlights of the initial surveys received from the workshop attendees.

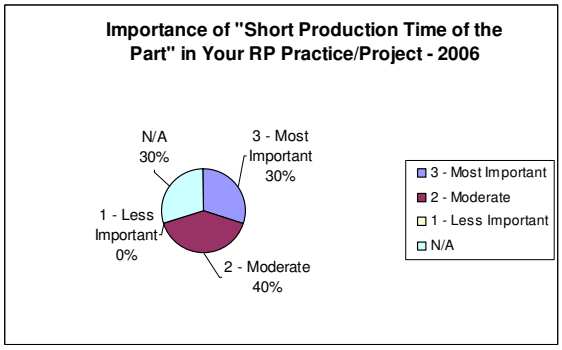


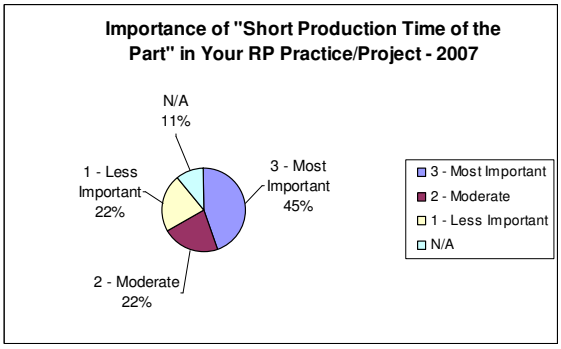

Have you ever practiced RP Technology before? - 2006
Yes 0%
No 100%
No
Yes

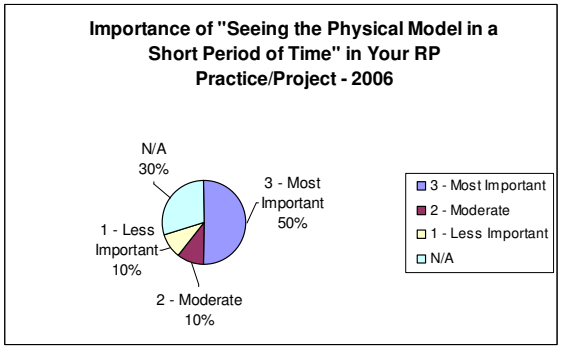

Have you ever practiced RP Technology before? - 2007
Yes 22%
No 78%
No
Yes

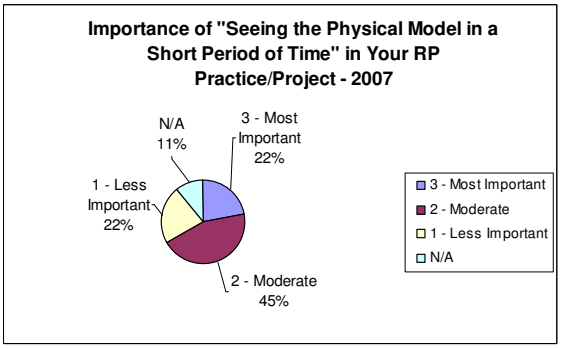

Have you ever seen or read anything on RP before? - 2006
Yes 30%
No 70%
No
Yes

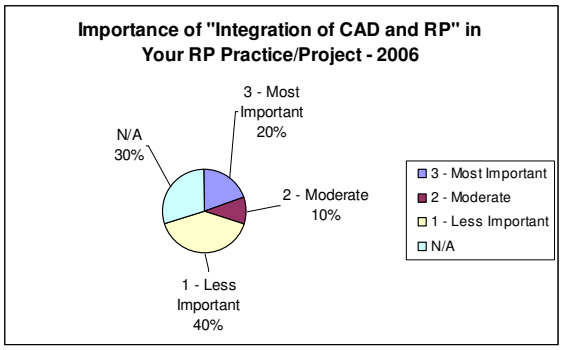

Have you ever seen or read anything on RP before? - 2007
No 11%
Yes 89%
No
Yes

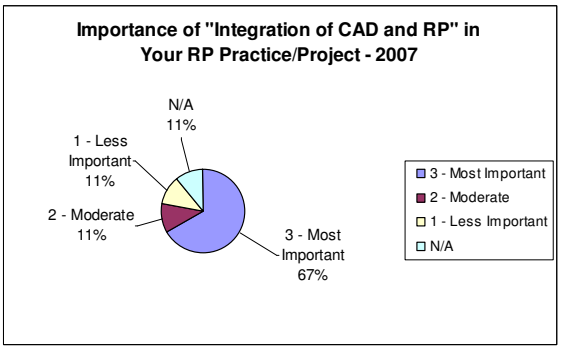

Importance of "Short Production Time of the Part" in Your RP Practice/Project - 2006
N/A 30%
3 - Most Important 30%
1 - Less Important 0%
2 - Moderate 40%
3 - Most Important
2 - Moderate
1 - Less Important
N/A

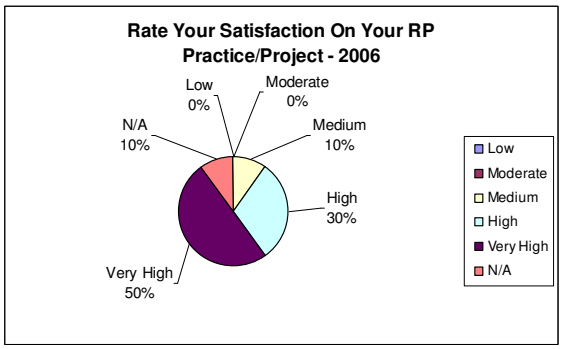

Importance of "Short Production Time of the Part" in Your RP Practice/Project - 2007
N/A 11%
1 - Less Important 22%
3 - Most Important 45%
2 - Moderate 22%
3 - Most Important
2 - Moderate
1 - Less Important
N/A

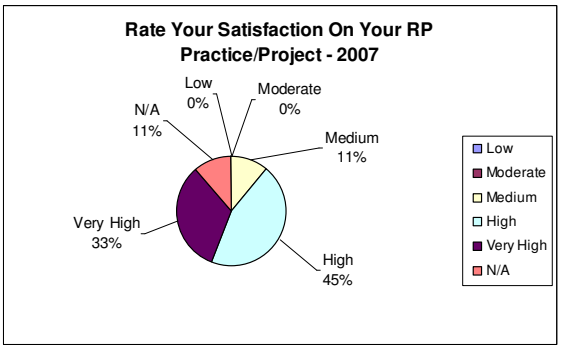

Importance of "Seeing the Physical Model in a Short Period of Time" in Your RP Practice/Project - 2006
N/A 30%
3 - Most Important 50%
1 - Less Important 10%
2 - Moderate 10%
3 - Most Important
2 - Moderate
1 - Less Important
N/A

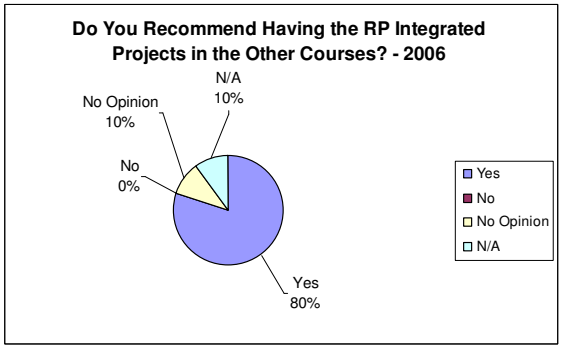

Importance of "Seeing the Physical Model in a Short Period of Time" in Your RP Practice/Project - 2007
N/A 11%
3 - Most Important 22%
1 - Less Important 22%
2 - Moderate 45%
3 - Most Important
2 - Moderate
1 - Less Important
N/A

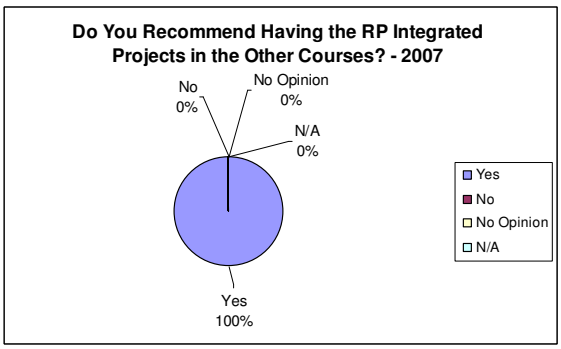

Importance of "Integration of CAD and RP" in Your RP Practice/Project - 2006
3 - Most Important 20%
2 - Moderate 10%
1 - Less Important 40%
N/A 30%
3 - Most Important
2 - Moderate
1 - Less Important
N/A

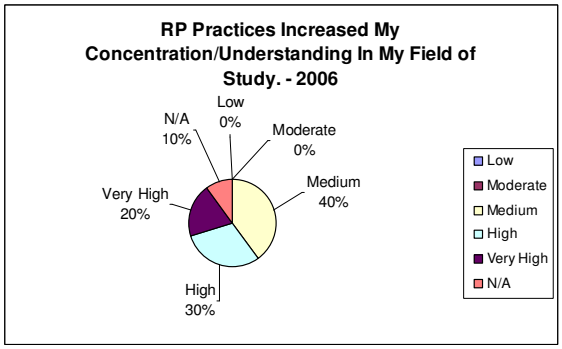

Importance of "Integration of CAD and RP" in Your RP Practice/Project - 2007
N/A 11%
1 - Less Important 11%
2 - Moderate 11%
3 - Most Important 67%
3 - Most Important
2 - Moderate
1 - Less Important
N/A


Rate Your Satisfaction On Your RP Practice/Project - 2006
Low 0%
Moderate 0%
Medium 10%
High 30%
Very High 50%
N/A 10%
Low
Moderate
Medium
High
Very High
N/A


Rate Your Satisfaction On Your RP Practice/Project - 2007
Low 0%
Moderate 0%
Medium 11%
High 45%
Very High 33%
N/A 11%
Low
Moderate
Medium
High
Very High
N/A


Do You Recommend Having the RP Integrated Projects in the Other Courses? - 2006
N/A 10%
No Opinion 10%
No 0%
Yes 80%
Yes
No
No Opinion
N/A


Do You Recommend Having the RP Integrated Projects in the Other Courses? - 2007
No 0%
No Opinion 0%
N/A 0%
Yes 100%
Yes
No
No Opinion
N/A


RP Practices Increased My Concentration/Understanding In My Field of Study. - 2006
Low 0%
Moderate 0%
Medium 40%
High 30%
Very High 20%
N/A 10%
Low
Moderate
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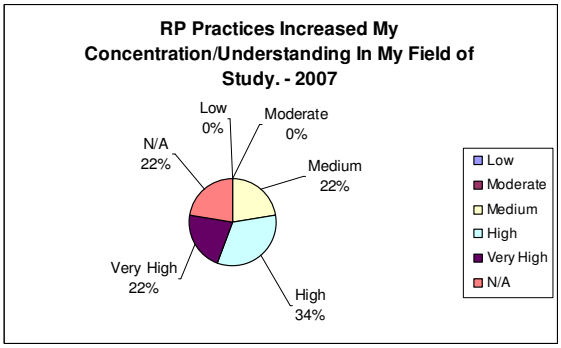
High
Very High
N/A


RP Practices Increased My Concentration/Understanding In My Field of Study. - 2007
Low 0%
Moderate 0%
Medium 22%
High 34%
Very High 22%
N/A 22%
Low
Moderate
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High
Very High
N/A

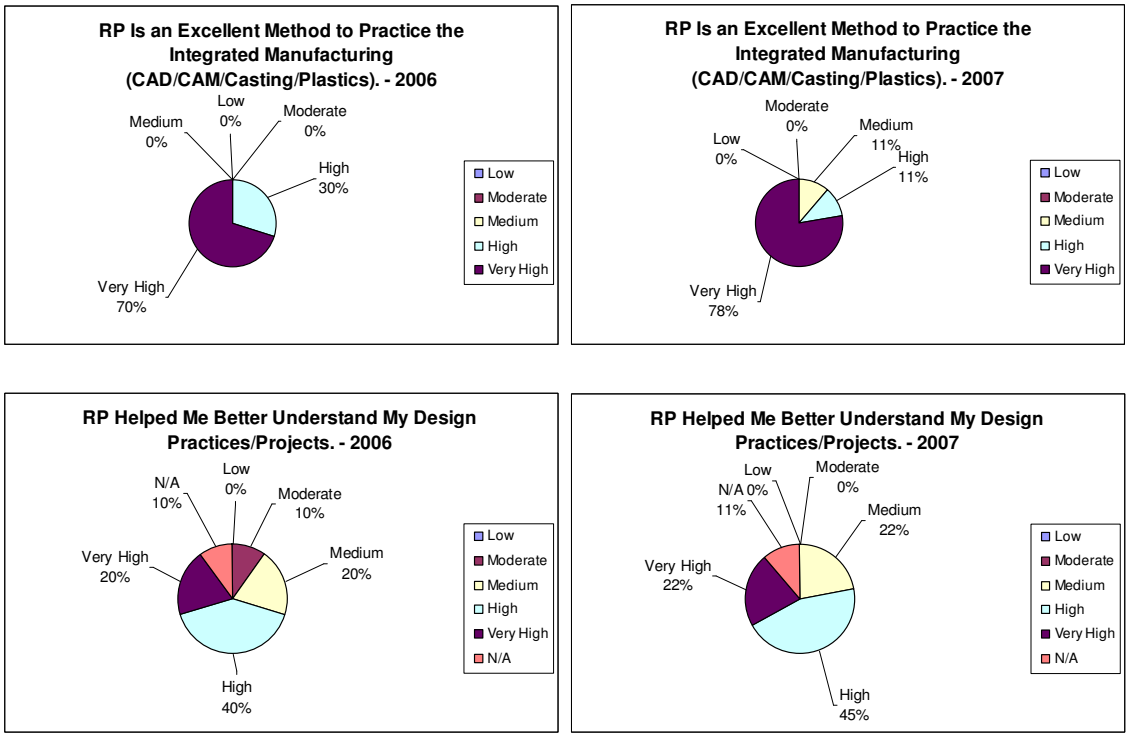

Figure 1: Responses received from teacher surveys.

Survey responses from teachers and instructors indicated a high level of satisfaction with content and methodology. They found the coverage of the workshop subject matter to be adequate and informative. All participants indicated a desire for increased integration of RP project exercises into their disciplines.

Rapid Prototyping technology provides an excellent tool for visualizing computer-generated designs. Users of rapid prototyping technology can produce physical, tactile representations of different stages of the design/re-design iterative process. Working with a physical model is superior to visualizing the representation of a model on a computer workstation screen. The making of necessary and needed design modifications, based on the consideration of process or design constraints, is facilitated by the availability of a physical model.

Participants all agreed that the inclusion of rapid prototyping content into course subject matter broadened students' exposure to design and integrated manufacturing practices and, in the case of Engineering Graphic courses, provided a tool for enhancing the visualization skills of students. The following is a partial list of comments from the teacher/instructor survey information.

- This was great, RP is truly amazing. I only wish there were more time to explain ways to use RP activities in K-3 curriculum.
- Wonderful workshop- I was fascinated by the technology and am proud TTU is on the cutting edge of technology!

- On a personal basis I learned so much about prototyping that I was unaware of before attending this workshop. It was fascinating to watch the car being constructed! Terrific!
- It was an absolutely wonderful workshop. I enjoyed the time I spend here. Learned about new interesting technology.
- Very interesting workshop.
- Good Information- Would have liked more hands on activities.
- Very interesting information.
- This workshop was very informative! I enjoyed the opportunity!
- Presentation was great! Lab was amazing to tour and watch an operation of one prototype.
- Excellent information
- This project will provide freshman engineering students with exposure (real time) to state of the art RP processes and allow for integration of engineering graphics coursework with virtual RP experience.

Student Practices

The TTU Rapid Prototyping Laboratory has been used extensively in various design and manufacturing courses.[2-4] University and Community College instructors participating in the training workshops have used the remote laboratory in their on-campus courses.

Part files are submitted to the TTU server from remote campus locations by students and instructors via email attachments. As soon as the part file is received the part process schedule is entered into the laboratory calendar[5]. A sample laboratory schedule for the month of October 2007 is given in Figure 2.

Figure 2: Sample Laboratory Schedule

Instructors and student teams can access and observe the entire prototype production process real time. An Internet browser video interface allows observers to zoom, pan, and tilt the remote laboratory cameras for the purpose of viewing different facets of the process. Audio adjustments can also be made when presentations are broadcast from the lab. These capabilities allow remotely located students and instructors to be a functional part of entire process from the start to end.

Completed prototypes are express-mailed to student teams or instructor/teachers.

The following is a partial comment list collected from the student surveys.

- Columbia State Community College-Engineering Graphics Course

What are the conventional manufacturing processes you practiced so far?

Java programming, C++, all computer programming courses
Sketching, dimensioning, and putting parts together
Pro/Engineer Wildfire program and AutoCAD

Where can you use RP in the future?

On the job arch
Engineering things
Graphics
Future CAD courses
Working in other programs such as this

Your comments on RP Projects/Instructions:

Still wonder on how it was made but very happy with outcome of part
Very quick delivery and matches design. Very well done.
I really like the fact that I can design something and see the physical outcome instead of just on a computer screen.
This piece that I designed on the Wildfire program and the module that came back to me were exactly the same. It was really interesting to see the product in real life.

Overall student satisfaction on the rapid prototyping practices is given in Figure 3.

- Tennessee Tech University-Basic Engineering/Graphics Course

What are the conventional manufacturing processes you practiced so far?

CNC milling, lathe work, prototype machine shop, 4 axis, 5 axis, milling
Welding
Welding, carpentry, machine (lathe, drill press, sheer, break, chop saw, pipe bender, stock bender)
Traditional machining, CNC, Wire 3DM
Computer design, hand built
Raw materials fabrication
CAD sketching, conventional milling
Make stuff from wood

All machine shop projects
Machine shop, lathe, mill work
Manual prototype

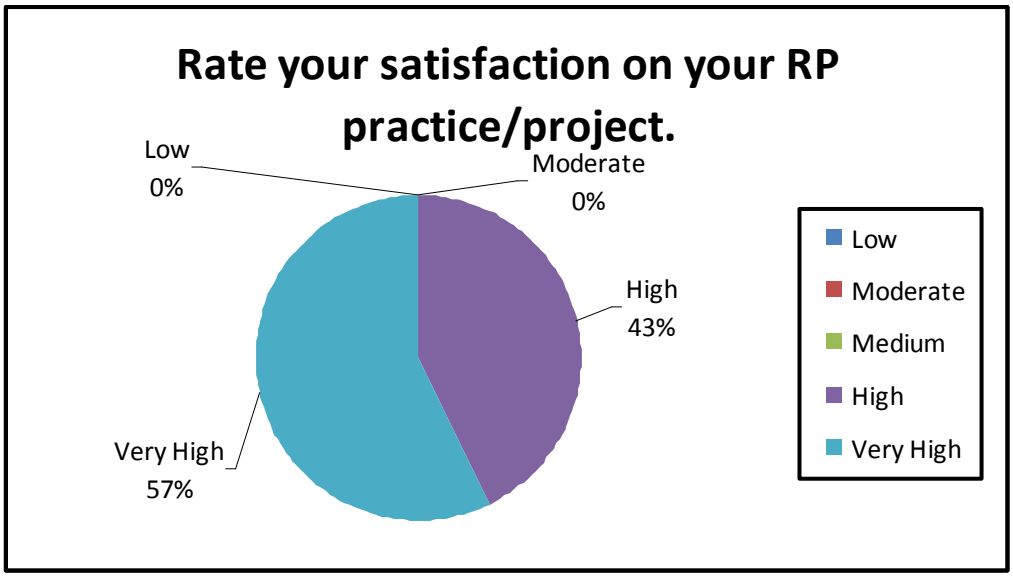

Figure 3: CSCC Students-Student Satisfaction Rate

Where can you use RP in the future?

In any other design projects I have
To make robots
Modeling structures for testing
To make prototypes of riverbanks
Automobile design, house building
Quick idea formulation into reality in the workplace
Any job that produces a manufactured product
Any sort of modeling project
Anywhere you need a true model
In just about anything
To make a prototype of something I designed
To make parts and help you see a physical effect of them
Developing models for traditional machining processes
Work field and anywhere that designs things
Automobile design
Toy companies
Design projects
Making full size car prototypes
Job perhaps, future projects
School projects, work field
In the most, if not all, engineering courses
R&D
Manufacturing assembly lines
Prototyping bridges or buildings

Creating mock carpentry models
In designing specific parts
Quite routine, quite useful, quite conventional
Testing
Part modeling for automobiles
To better visualize prototype designs
Modeling projects in various classes
Future major
Part/tooling development
In practically all fields

Your comments on RP Projects/Instructions:

Very interesting and cost effective
Our one class that covered RP couldn't teach me how it helps my field. More time would have been helpful in understanding the uses of RP.
Keeps more interest in classes
MEs need to learn how to use the machine.
If a cheaper way to build RPs could be achieved and a larger scale could be obtained, RP would be much better. Also if more mediums could be used, RP would be more desirable.
Interesting process, look forward to using it in the future
I felt the machine that prints these models and in the manner in which it prints these models is very interesting.
…Neat!
Yeah, it really wasn't very informative. I know that this is good technology but I know next to nothing about it.
Awesome
Would have liked to see my design made into a prototype. I think my pen holder was very good and displayed a profit box pen holder and clip holder.
It was cool to see a tangible item from a data file.

Overall student satisfaction on the rapid prototyping practices is given in Figure 4.

- Nashville State Community College-Technical Drawing Course

What are the conventional manufacturing processes you practiced so far?

Tool and die

Where can you use RP in the future?

For part presentations
Almost anywhere there is a need
In just about everything

Your comments on RP Projects/Instructions:

This is amazing technology that will help bring great things.

Overall student satisfaction on the rapid prototyping practices is given in Figure 5.

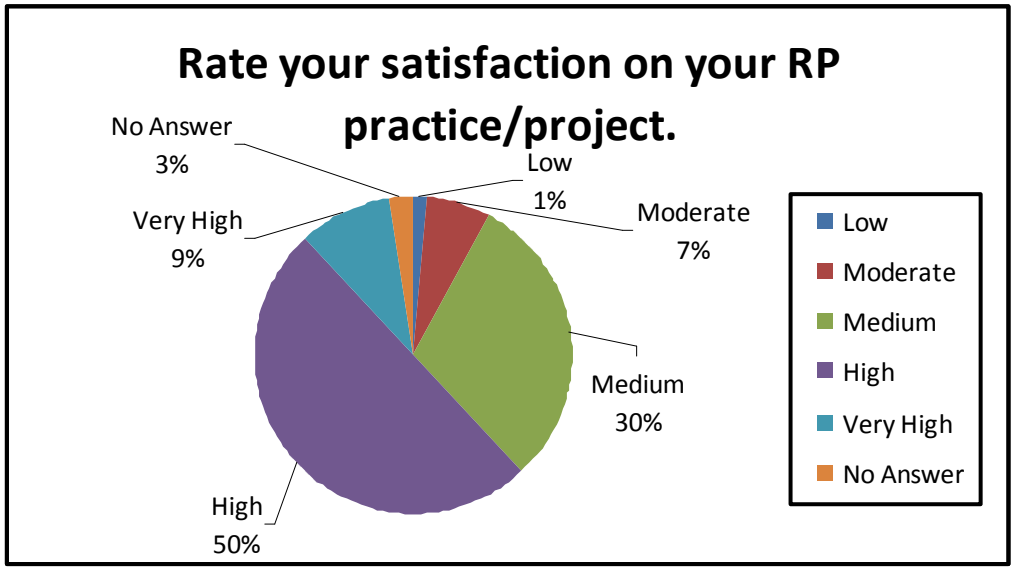

Figure 4: TTU Basic Engineering-Student Satisfaction Rate

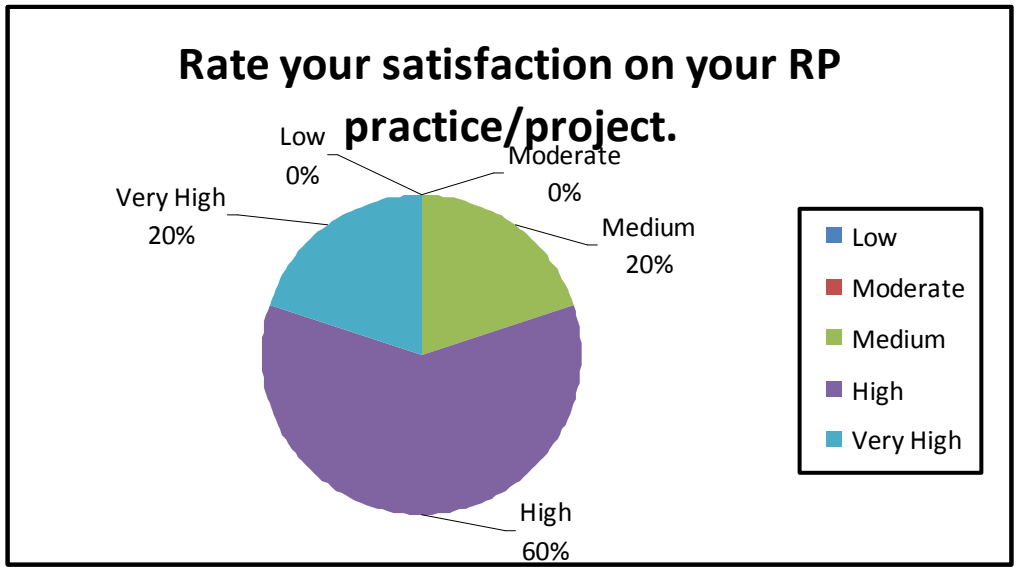

Figure 5: Nashville State Community College-Student Satisfaction Rate

Conclusion

The Objectives of the NSF CCLI Phase 1 Award 0536509 have been successfully implemented during 2006 and 2007. The use of teacher training workshops for the purpose exposing students to rapid prototyping has allowed for the integration of a state of the art technology into existing course subject matter. The use of Internet real-time video and audio delivery technology has made possible the remote accessing of laboratory facilities by schools that did not otherwise have access to such labs or technology.

Feedback received from instructors and students indicated very high satisfaction rates with respect to their integrated rapid prototyping laboratory experiences. In the near future, it is anticipated that a wider dissemination of the remote laboratory availability will include more statewide and national institutions.

Acknowledgements

Remotely accessibly Rapid Prototyping Laboratory was established with the NSF CCLI Awards 0536509 and 0311586. Authors greatly appreciate the help and support of student assistant Shawn Fann.

References

[1] I. Fidan, C. Nocton, A. McGough, K. Patton, "*Hands-On-Workshop Based Learning of Rapid Prototyping*," Proceedings of the 2004 American Society for Engineering Education Conference & Exposition, http://www.asee.org/acPapers/2004-41_Final.pdf

[2] I. Fidan, N. Ghani, "*Acquisition Steps of a Remotely Accessible Rapid Prototyping Laboratory*," International Journal of Computer Applications in Technology, pp. 280-286, v. 30, n.4, 2007.

[3] I. Fidan, N. Ghani, "*Remotely Accessible Laboratory for Rapid Prototyping*," Proceedings of the 2004 American Society for Engineering Education Conference & Exposition, *http://www.asee.org/acPapers/AC%202007Full359.pdf*

[4] I. Fidan, "*Integrating RP Technology into the Tennessee Tech's Manufacturing Curriculum*," Proceedings of the 2004 American Society for Engineering Education Conference & Exposition, *http://www.asee.org/acPapers/2004-359_Final.pdf*

[5] http://www.localendar.com/public/rrpl