AC 2008-2788: INNOVATIVE DELIVERY OF MIT4450--RAPID PROTOTYPING COURSE

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Innovative Delivery of MIT4450--Rapid Prototyping Course

Abstract

Manufacturing and Industrial Technology (MIT) is one of the well-known majors at the College of Engineering of Tennessee Tech University (TTU) located in Cookeville, TN. MIT students graduate with a BS in Industrial Technology and take 121 credit-hour coursework to complete their degrees.

During the Fall 2007 semester MIT4450--Rapid Prototyping course has been re-structured to offer fully online laboratory component for students' practice. Students were able to prototype their parts through remotely accessible Rapid Prototyping Laboratory.

Web-enhanced MIT4450 course students were also able to interact with students in Western Nevada College and prototype joint project parts with the campus engineering students. Another K-12 school in Nevada also participated in project and their students have learned the cutting edge RP practices through MIT4450 Rapid Prototyping course.

This paper will report the currently structured, innovative MIT4450 course and its findings received from the university-institutional review board (IRB) approved survey tool.

Introduction

Rapid prototyping is the automatic construction of physical objects using 3D models and additive fabrication technologies. The first techniques for rapid prototyping became available in the late 1980s and were used to produce models and prototype parts. Today, they are used for a much wider range of applications in defense, biomedical engineering, art and simulation.

TTU has been offering RP course since early 2004. This course is offered for the senior level technology students; however various engineering and science students also take it. With the availability of a remotely accessible RP laboratory, course students were able to access the laboratory remotely and perform various team projects for their in-class assignments.

MIT4450 Course Restructure

Since the course has been offered via Deside2Learn (D2L) online course system, it was a hybrid course with its face-to-face instructional components. Laboratory practices have been accomplished with the help of a student assistant and he was processing the parts and submitting them directly to student teams. In order to generate the 3D models, Pro/Engineer Wildfire 2 software has been used and course students have learned how to use it to generate their models in .stl part file format.

Table 1 shows the course outline[1]:

Table 1: MIT 4450 course outline

CAD Portion

Session 1
- Parametric Modeling Fundamentals
- Constructive Solid Geometry Concepts
- User Interface, View Controls and Model Structure

Session 2
- Model History Tree
- Parametric Constraints Fundamentals
- Creating your models

Session 3
- Revolved Protrusions, Mirror Copies, Rounds, and Chamfers
- Part Drawings and Associative Functionality
- Parent/Child Relationships and Design Variables
- Datum and Sketcher Tools
- Patterns and copies

Session 4
- Advanced 3D Construction Tools
- Assembly Modeling
- Sweeps and Blends
- Industrial Practices
- Final Design Project Presentations

RP Portion

Session 1
- Introduction to Rapid Prototyping
- Origin, Need, and Solutions
- Design Process
- Production Process
- Advantages and Disadvantages
- Past, Today, and Tomorrow
- Key Terms
- Materials, Machines, and Maintenance

Session 2
- RP Modeling
- Fused Deposition Modeling
- Laminated Object Manufacturing

Stereolithography
Selective Laser Sintering
3D Printing

Session 3
RP Applications
Casting
Rapid Tooling
Reverse Engineering
Micro Machining
Plastics and Injection Molding

Session 4
Final Projects
Case Studies
Industrial Practices
Final Project Presentations

Course Management System

Course delivery and assessment has been accomplished via D2L system. D2L is a developer of online course management system for schools, higher education, associations, government and private industry. Headquartered in Kitchener, Ontario, Canada, President and CEO John Baker has founded the company in 1999.

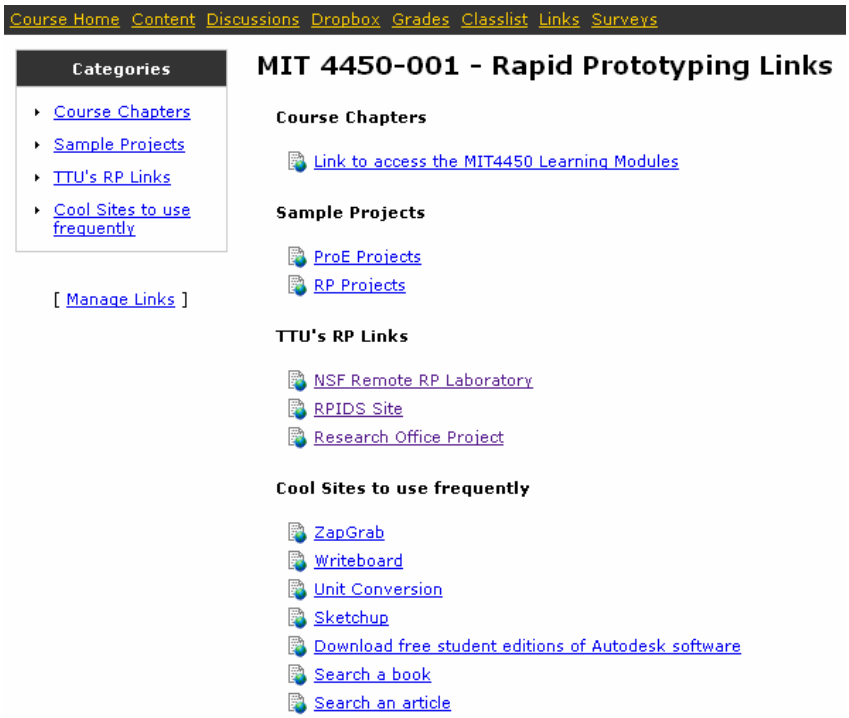


Figure 1: MIT4450 D2L Site

Today the company supports over 4 million learners worldwide. Over 400 institutions are currently using D2L[2]. Figure 1 presents the view of MIT4450 D2L site.

Interesting features of D2L include

Ability to create infinite number of roles (e.g. admin, instructor, student, guest, guest speaker, teaching assistant, tutor, remote participants, etc.) creates a great deal of flexibility in how institutions use D2L.

New courses can easily be uploaded using the components feature, which has the Export/Import/Copy tasks in it.

Ability to define different organizational configurations in D2L allows different units (e.g. departments, institutions, consortiums) to scale implementation of a single installation. This could allow all institutions in Tennessee to use a single installation of D2L.

D2L "widgets" allow web content (e.g. RSS feeds, Google Searches) to be placed into courses.

New email feature integrates campus mail (e.g. Outlook) into local emailing system.

MIT4450 students have used the D2L online course materials and flexibly accessed the team discussions and various communication mechanisms in order to successfully accomplish their tasks in assessments and projects.

Laboratory practices have been arranged using the schedule tool available at the project website. Network cameras and audio connections helped both teams communicate effectively. Students having dial-up connections indicated their difficulties with the laboratory access capabilities, however high speed Internet connections have not faced any difficulties.

Multi-institutional Design and Production Project

For the MIT4450 term project, teams have been formed with three-to-five students. One group has worked with a faculty member at Western Nevada College (WNC) to rapid prototype a trebuchet. The trebuchet was designed by students in WNC-Engineering Design course. WNC-Engineering Design instructor sent to TTU group three pictures and details of the trebuchet. From these pictures MIT4450 group had to model the trebuchet on Pro/Engineering Wildfire 2 software and then rapid prototype the trebuchet using the remotely accessible RP laboratory.

The first step the group took was modeling the trebuchet on Pro/E software. Their first idea was to model the trebuchet out of one solid block. On screen the trebuchet model looked great. However in the original design there was a pin that connects the stand with the throwing arm and this model was unable to move. The problem was an easy fix and the team quickly made the pin free moving so the throwing arm could rotate.

After the prototyping process was complete there was yet again an obvious problem with the model. The pin was not strong enough to support the weight of the throwing arm. The pin

breaking was not the fault of the team design, but it was a real life problem of the material being used by the rapid prototyping system. The material used was not strong enough to support the weight of the throwing arm. On the actual trebuchet the material the pin is made of metal which is much stronger than the powder the rapid prototyping machine uses.

The final team solution to fix the weakness of the pin was to rapid prototype the trebuchet in two separate pieces, the stand being one, the throwing arm being the second, and then to attach the throwing arm to the stand with a small metal bar machined with a CNC technology. This way the pin will be strong enough to support the throwing arm's weight. This worked out good and final product was fully functional.

All that was left was obtaining the price estimations for rapid prototyping the piece. If this design was rapid prototyped with a SLA or FDM process there might have been no need for creating two separate parts because SLA or FMD would have had the strength and resolution to create one free moving assembly.

Student team has used Xpress3D[3] for price estimations on the stand and throwing arm. The price information, shipping date, process, company, and description of the technology were all investigated. The total price for the two pieces ranges from $1,592 to $4,144. The shipping times range from 2 to 8 days.

The details of the project works are shown in the YouTube presentations given in Figure 2 and 3:

Figure 2: YouTube Presentation of the MIT4450 Term Project[4]

Student Feedback

In order to receive student responses, an IRB approved D2L survey instrument has been given to MIT4450 students. 16 students fully completed the survey. Only two students were not able to participate in this study. Table 2 presents the partial view of students' responses:

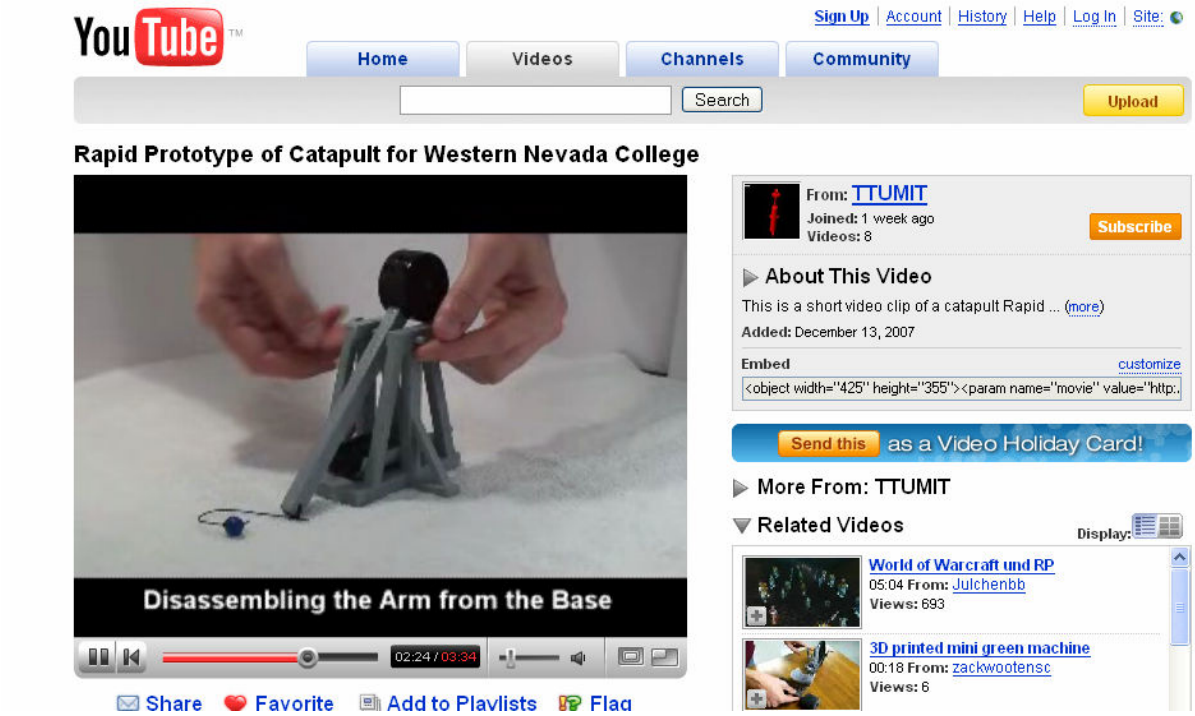


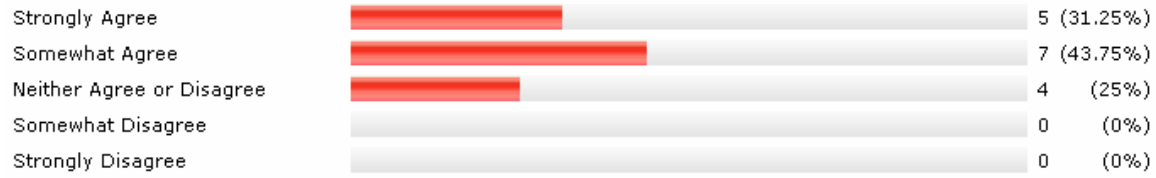
Figure 3: YouTube Demonstration of the MIT4450 Term Project[5]

Table 2: MIT4450 Student Responses

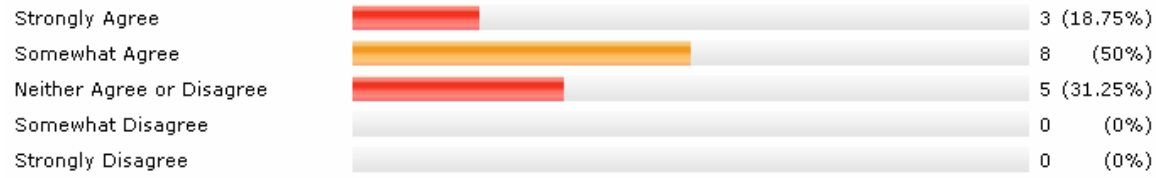
The situations presented in the course were reflective of the real world.

Strongly Agree	4	(25%)
Somewhat Agree	9	(56.25%)
Neither Agree or Disagree	1	(6.25%)
Somewhat Disagree	1	(6.25%)
Strongly Disagree	1	(6.25%)

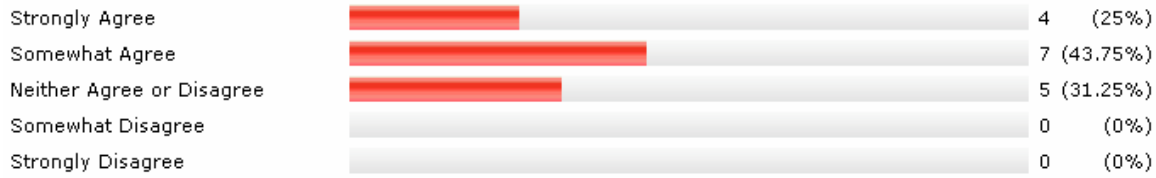
my learning of important concepts, principles, and ways of thinking.



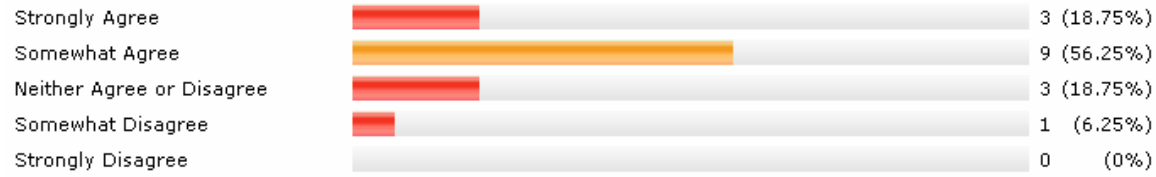
develop strategic planning and execution skills within a rapidly changing environment.



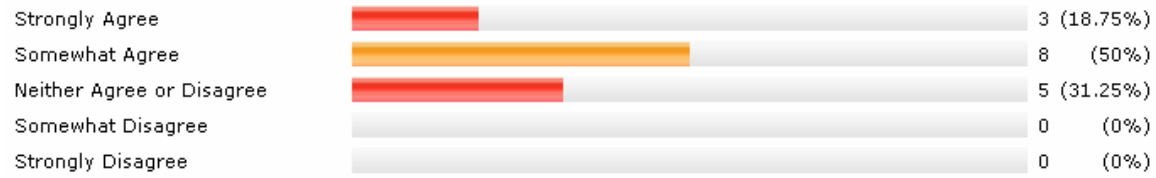
develop a thought process that I can carry into the real world.



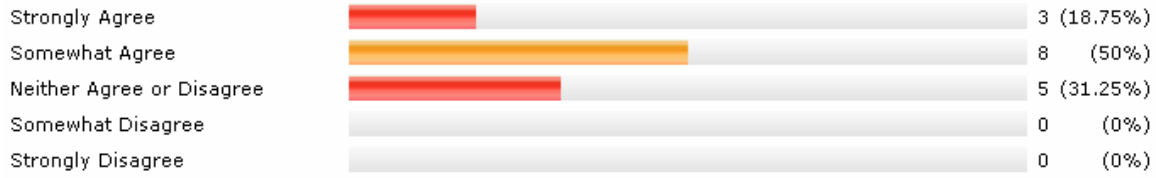
feel like I was in control of my personal growth during the course



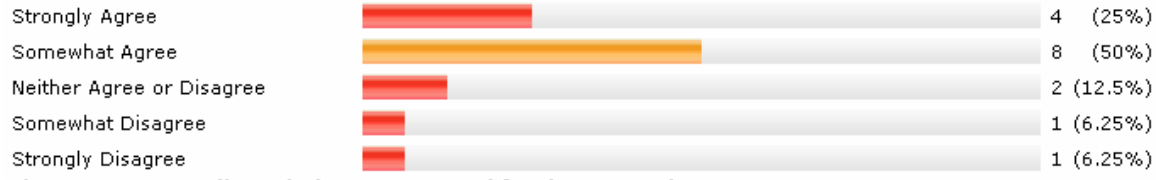
develop my critical thinking skills



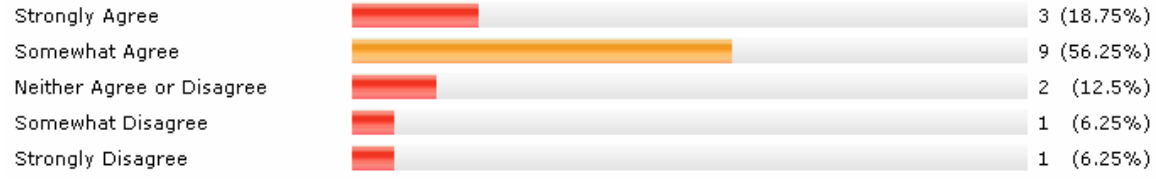
show others that I have a great deal of ability and talent in my field

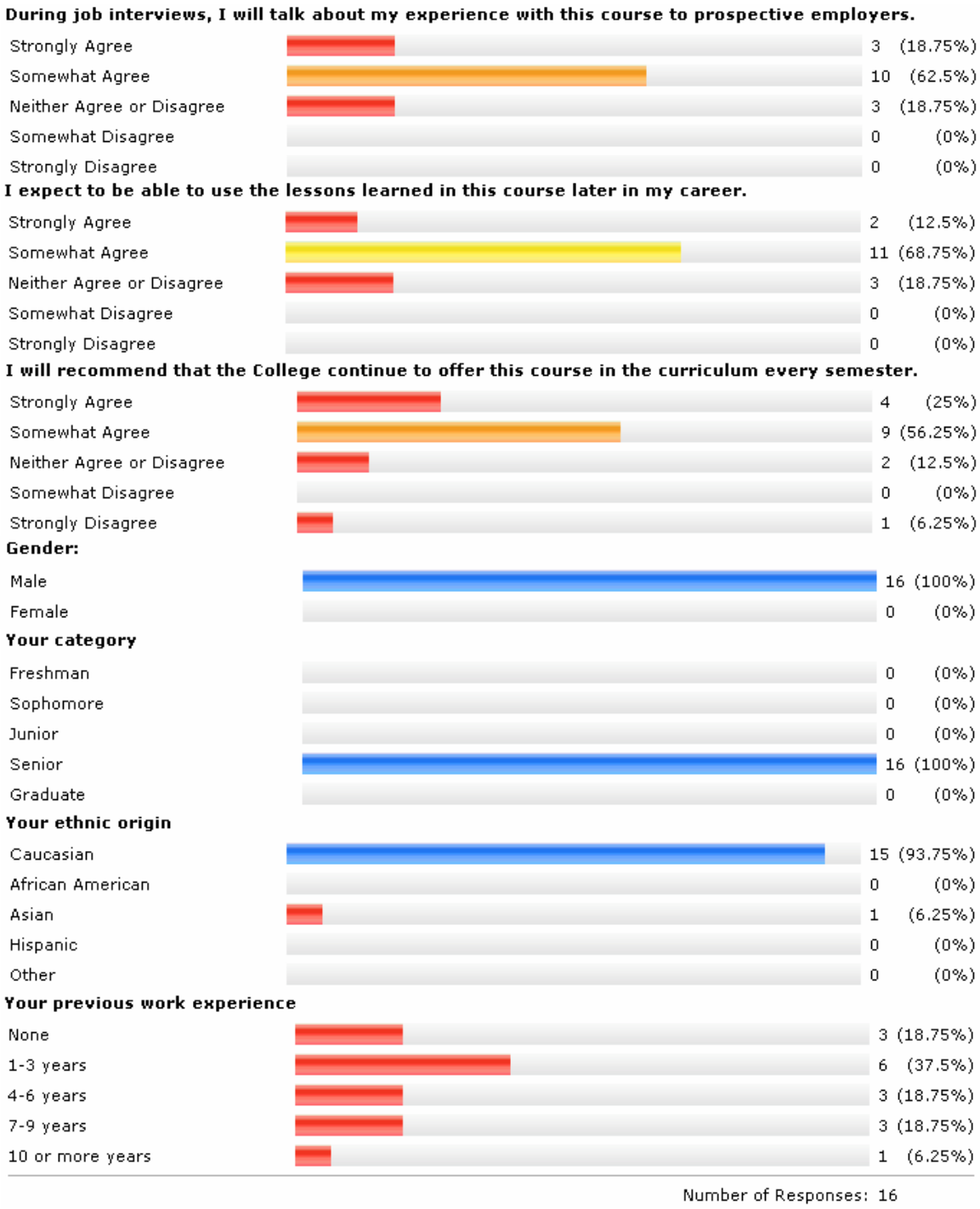


The benefits to me were worth the time I have invested in the course.



The course was well worth the money I paid for the materials.





Overall, the feedback received from the students was constructive and they were mostly appreciating the instructor's effort in course, remote laboratory and term projects. There was no major negative feedback or concern related to the laboratory practices. Currently, the limit of the remote access is 20, and there is no way to accept the 21st student into the remote connection. Few negative comments were on the slow Internet connection due to the slow networks and dial connections.

Conclusion

Remote laboratories are getting extremely popular and these laboratories have various advantages in cost, time, maintenance and trained operator. TTU was able to convert its on-ground rapid prototyping laboratory into a remotely accessible format. Campus and remote students easily prototyped their parts with the help of a campus student assistant and received them in a short period of time.

The results of the D2L survey reported that most of the students appreciated this practice and they saved most of their laboratory hours since they used remote access features of the remote laboratory.

Acknowledgements

Remotely accessibly Rapid Prototyping Laboratory[6] was established with the NSF CCLI Awards 0536509 and 0311586. Trebuchet design and prototyping project is the recipient of the Bronze Performance Award at the SME Leadership Series-Manufacturing Poster Competition held on February 9, 2008 in Nashville, TN. Authors greatly appreciate the help and support of MIT4450 student assistant Shawn Fann.

Bibliography

[1] http://www.tntech.edu/ugcat/html/mit.asp

[2] http://www.marketwire.com/mw/release.do?id=629943

[3] http://www.xpress3d.com/

[4] http://www.youtube.com/watch?v=OGbi7_Nl_wY

[5] http://www.youtube.com/watch?v=0llOJthPffY

[6] http://iweb.tntech.edu/rrpl