

# Engineering Clinics for Middle School Teachers

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**Abstract—** The ECT (Engineering Clinics for Teachers) Program is a partnership between Rowan University's Colleges of Engineering and Education to provide an *Engineering Clinic* experience for middle school teachers and guidance counselors. The workshop is modeled after the unique Rowan Freshman Engineering Clinics that faculty have developed for exciting and retaining incoming freshman in our engineering programs. This is the first Rowan initiative to integrate engineering content in the middle school curriculum and train teachers regarding engineering concepts as well as the identification of students with potential to become engineers. It is also the first official effort between two Colleges instrumental in the preparation of future teachers and engineers. The ECT program is being funded by a generous grant from the Martinson Foundation. The first ECT was offered in the Summer of 2006 with successful outcome. Modifications have been also made from the 2006 assessment to improve the workshop for 2007.

## Introduction

Engineering is still a mysterious profession. It is surprising to hear students in year 2007 state that engineers work only for the railroad. Furthermore students have no role model engineers (both male and female) that they typically come across during regular television programs, movies or other public media gatherings. Math and science textbooks also do not reflect this adequately. Therefore there is a dire need to promote engineering as a viable career option for both men and women. This can only be achieved by proper exposure of engineering throughout K-12 education. Despite the high record of students attending college today, there is still an acute shortage of engineering graduates [1].

There is a growing interest among engineering faculty that science and math education needs to be connected to engineering in the K-12 years. Enhanced engineering education in our K-12 classrooms can provide students at an earlier age with a more specific understanding of what a technical career entails. Exposure of K-12 students to engineering can only occur if the K-12 educators can be exposed to engineering concepts.

James B. Conant [2] stated that *"We shall have rapid or slow advance on any scientific frontier depending on the number of highly qualified and trained scientists exploring it...So in the last analysis, the future of science in this country will be determined by our basic education policy."*

Thus, changes in the delivery of math and science throughout the K-12 years need to be impacted now if we want qualified engineers in the future.

## The ECT Program

This ECT (Engineering Clinics for Teachers) Program is a partnership between Rowan University's Colleges of Engineering and Education to provide an *Engineering Clinic* experience for middle school teachers and guidance counselors. The program is modeled after the unique Rowan Engineering Freshman Clinic [3, 4]. This two semester four-credit course was designed to excite students about engineering and also help with student retention. Freshman Clinics expose students to basic engineering skills including problem solving, teamwork fundamentals, engineering measurements and entrepreneurship. Students are introduced to a variety of activities relevant to engineering measurements in the first semester [5]. These measurements typically include basic process, strength, and electrical measurements. This is followed in the second semester by intense study of engineering design through reverse engineering ("dissection") and competitive assessment of a consumer product [6,7]. Competitive assessment is defined as the systematic testing of existing commercial products for the purpose of learning engineering design principles, improvement and comparison. Students are encouraged to develop innovative product improvement schemes. Past projects include studies of the following products or processes: electric toothbrush, soccer helmets, living aquarium, portable water filters, beer brewing, thermoelectric coolers, blood pressure cuffs, carbon monoxide detector and principles related to the human body.

The overall objectives of the ECT program are to

- *Provide* exposure to engineering careers and make engineering more relevant to middle school educators,
- *Ensure* that teachers are academically prepared to successfully integrate engineering content into their existing curriculum,
- *Support* teachers and students in exploring and understanding engineering content in K-12 education through professional development activities, and
- *Serve* as a national model for other undergraduate institutions in integrating engineering content in K-12 education..

## Implementation of the ECT Program

The ECT project is a joint effort between the Colleges of Engineering and Education at Rowan University. It is a 5-day summer residential workshop that provides opportunities for teachers and university faculty to form closer bonds as a learning community that works together on engineering common problems. Math, Science, Technology, Social Sciences and English teachers and guidance counselors from middle schools are the major target population for this workshop. The Southern New Jersey school districts represent a diverse body of students and teachers with a wide range of socioeconomic status. Teacher participation is typically from the six neighboring counties: Burlington, Gloucester, Camden, Cumberland, Atlantic and Salem.

Recruiting efforts include traditional methods such as mailings, flyers, brochures, electronic networking and visits to the school district offices to promote participation. A website [8] is also maintained to disseminate relevant information. All lesson plans, presentation slides, laboratory manuals; other important links are posted at this site. Recruitment goals include a diverse representation of teachers in terms of geographic distribution, specialization and level of interest. Teachers are provided with a \$450 honorarium and continuing education units (CEUs).

### *Workshop Activities*

Teachers are divided into small teams to work on simple cost-effective hands-on activities involving engineering, mathematics and science. These modules are derived directly from the current engineering clinics led by engineering faculty. Our goal is to keep the activities simple and cheap so that they can easily be adopted by educators without incurring a burden on school district budgets.

For example, teachers are taught how to design an efficient soda bottle rocket using their science and math skills. This exposes them to connect Newton's third law of motion to concepts in aerospace engineering and get their students excited about careers at NASA. A module on preparing lip gloss exposes them to chemical reactions in preparing cosmetics and to chemical engineering processing. A human body module teaches participants the similarities between the human body organs and many engineered systems. An aquarium is used to demonstrate the science and engineering that goes behind the design and maintenance of such a facility. A bridge building activity using paper and Jenga blocks introduce participants to structural engineering. All these modules are taught by engineering faculty. Appropriate handouts and problem assignments are also provided during these modules so that teachers can use these in their classrooms.

All modules selected are relevant to the course content directed by school districts. Communication skills are also a part of the workshop by integrating technical writing and presentation modules. The engineering faculty collaborate with the education faculty to ensure the relevance of the activities and to make the experience appealing to the teachers. Participating teachers are also provided with an opportunity to observe students participating in Rowan's Materials Science Institute or Attracting Women into Engineering workshops for high school and middle school students.

Another innovative aspect of the ECT program is the incorporation of reflective activities. K-12 educators have a tremendous challenge in educating our future generations. It is not uncommon for these educators to feel stress and anxiety that can eventually lead to burnout and poor job performance. Too often teachers are so caught up in the content and delivery of their programs that scant attention is paid to reflection on the how and why of what they are doing. Thus, time for reflection on the activities, attention to how one learns and the need for care of the self are included in the day-to-day schedules. Emphasis is placed on balancing the academic aspects of the clinic experiences with attention to mental and physical health. These activities include trips to the university recreation center, yoga classes, nature walks, journal reflections, laughter, meditation, and art classes and field trips.

### *Assessment and Impact*

Assessment of the workshop is carried out via surveys during and after the duration of the workshop. Select visits are made to schools to watch teachers integrate and deliver the material provided to them during the ECT workshop. Teachers are invited to a fall and spring follow up meeting to discuss the impact of the workshop and the ease or difficulty in delivering the engineering clinic modules. This assessment provides key information in planning activities for future years. Successful teachers are invited back to participate as mentors in the next session.

### **ECT 2006**

We offered our first ECT workshop in the summer of 2006. The workshop allowed us to recruit a total of twenty teachers. A total of seventeen middle school teachers (3 no shows) participated in the ECT workshop. Math, Science, Technology and Special Education teachers were among the participants. A total of 11 schools were represented from 10 school districts. Participants arrived on Sunday June 25, 2006 to check into the university housing. A dinner with jazz music was provided as an icebreaker event. The project directors welcomed the participants and also discussed the scheduled activities for the workshop.

*Clinic Modules:* Four engineering clinics were included in the workshop. These clinics represented the four engineering disciplines at Rowan University namely Chemical, Civil and Environmental, Mechanical and Electrical and Computer Engineering. The schedule is presented below in Table 1:

**Table 1: ECT Schedule**

<b>Day</b>	<b>9AM -10AM</b>	<b>10 AM -12 PM</b>	<b>1PM – 3PM</b>
1	Welcome	Hands on the Human Body	Bridges
2	Water Treatment	Robots	Circuits
3	Field Trip to the NJ State Aquarium		
5	Closing Ceremony		

The “*Hands on the Human Body*” clinic module focused on comparison of the human body with engineered systems. When most people think of engineering, the human body usually is not the first thing that comes to mind, but the systems of the body can be used to demonstrate engineering principles from all of the major disciplines.

Simple experiments using the human muscles were used to demonstrate the concepts of levers and force balances which are very common in Physics. Blood pressure monitors and the human heart were used to demonstrate concepts of hydrostatic pressure in a fluid flow system.

The Bridge module allowed participants to construct different types of bridges using Jenga blocks and a Computer software the West Point *Bridge Builder* [9] to design a truss bridge. This software can be downloaded for free from the website and is a great way of exposing educators and students to bridge engineering. Participants were presented with an individual Jenga block set for instructional purposes in their classrooms. Participants were also involved in discovering what makes a device or machine a ‘robot’. They built a few robotic Lego™ vehicles (‘cars’) and programmed them to complete specific tasks. Fundamental skills and concepts in mechanical engineering, such as computer programming, gearing, structural stability, and sensors was

discussed. The session culminated in a mini-competition in which teams of participants built a robot and competed in head-to-head competitions to achieve a given goal.

A circuits module that involved the construction of a circuit that not only generates a square wave (a train of logic zero and one pulses), but also turned the pulses into a four digit binary number that increments with each pulse. Then, the four digit binary number was “decoded” to light up the corresponding decimal on the seven-segment display.

Participants were also involved in discovering what makes a device or machine a ‘robot’. Participants built a few robotic vehicles (‘cars’) and programmed them to complete specific tasks using the Lego Mindstorm™ kits. Fundamental skills and concepts in mechanical engineering, such as computer programming, gearing, structural stability, and sensors was discussed. The session culminated in a mini-competition in which teams of participants built a robot and competed in head-to-head competitions to achieve a given goal.

Participants were taken to the New Jersey State Aquarium for a half day field trip. The objective of this field trip was to have participants identify the engineering behind the operation, maintenance and design of an aquarium. An aquarium is currently being used in our Freshman Clinic course to help students understand engineering design and impact of engineering design in the context of living systems. People seldom make a connection to the engineering principles playing out in the maintenance of a natural, commercial or personal aquarium although an aquarium is a common household product and also a site of great public interest.

*Reflective Activities:* Each day during the end of the ECT workshop activities, we set an hour set aside for teachers to reflect, both on the activities that had occurred throughout the day, and on their understanding of learning as a holistic endeavor, i.e., the need to attend to the mind, body, and spirit in order to teach for learning. The ECT program also allowed teachers to be engaged in a creative ART activity using a scale grid method. A professional High School Art teacher led this activity while engineering faculty helped the participants make connections between art and engineering. A couple of topics were discussed. These included Leonardo da Vinci’s contribution to engineering, material properties of paints and color and the creativity of engineering design. The art activities were well received except the timing from 6-9 PM was indicated to be too long.



**Figure 1: ECT Participants working on their ART activity**

*Assessment:* The ECT program was evaluated every day after every activity using surveys and direct focus group talks with the teachers. Overall the program was very well received. Detail assessment results have been reported in a separate article [11]. Surveys were conducted at the end of the day for evaluating all activities. A sample survey is presented below:

#### ENGINEERING CLINICS FOR TEACHERS SURVEY

<b>4=Excellent</b>	<b>1=Needs Improvement</b>
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Opening Ceremony

	1	2	3	4
Content Of Presentation				
Quality Of Presentation				
Organization Of Presentation				
Overall Quality Of Session				

Comments:

Clinic – Hands on the Human Body

	1	2	3	4
Content Of Presentation				
Quality Of Presentation				
Organization Of Presentation				
Overall Quality Of Session				

Comments:

Art Activity –

	1	2	3	4
Content Of Presentation				
Quality Of Presentation				
Organization Of Presentation				
Overall Quality Of Session				

Comments:

Did you have a chance to verbally participate? Yes \_\_\_\_\_ No \_\_\_\_\_

Your assessment of the workshop materials that were used today:

Excellent                      Satisfactory                      Needs Improvement

Did you learn something today that you will use in your job to improve classroom instruction? \_Yes \_No

The survey results indicated the following

- The keynote presentation was excellent and introduced participants to the need for K-12 educators to introduce engineering in their classes.
- The engineering clinics exposed participants to various engineering disciplines. The Bridge and Robot modules were well received. Some participants felt that the circuits and hands on the human body modules were difficult for the middle school level.
- The overall quality of the workshop was excellent and of great use to the teachers.
- Participants indicated that the reflective activities were useful but at times too lengthy.
- All participants indicated that the workshop helped them connect their coursework to engineering.
- All participants indicated daily that they had learned something to connect engineering to their existing course material.

*Follow-up:* The ECT 2006 participants have attended a follow-up workshop in October 2006 and are also scheduled to attend another workshop in April of 2007. These one day workshops are designed for the teachers to present their individual efforts in the classroom to expose engineering to their students. This allows us to gauge the impact of our workshop and challenges that teachers may face in their classrooms. All teachers indicated that they had mentioned engineering during their course delivery.

As part of these follow-up workshops we also provided a seminar on the different learning styles of students and had the participants involved in a learning style assessment module. This activity employed the **Let Me Learn**<sup>®</sup> [12] surveys that have now become the national tool for assessing learning styles. **Let Me Learn**<sup>®</sup> is the groundbreaking process that allows people of all ages to understand how they learn, then develop strategies to overcome any challenge. The **Let Me Learn**<sup>®</sup> process empowers educators to zero in on individual learning needs--and address them. It also helps them build better teams. Teachers indicated that this was a great exercise for them and would help them understand their students better. We also offered two more hands on activities for the teachers: a Jenga Block Tower Building competition and a chocolate cookie coating exercise to expose chemical coating processes.

The follow-up workshop in April will expose teachers to alternate energy modules and use of real-time data available on the WWW for math classes. Teachers will also make presentations on their classroom experience in connecting engineering to their math and science courses.

## **ECT 2007**

Plans are in progress for the ECT 2007 workshop. We have made minor changes for even better delivery of our hands on modules. We have simplified our circuit module and added an alternate energy module. The participants will also visit the first wind farm in New Jersey as part of their

field trip. The art lessons have been scheduled before 5 PM and we are also making the residential component optional.

## Conclusions

The Engineering Clinics for Teachers workshop at Rowan University was very successful in its first year. This is evident from the workshop evaluations and the level of participation. Teachers indicated that identifying simple inexpensive hands on projects that complement their current science and math curriculum is a simple way of connecting engineering to math and science course content. The ECT participants felt that the workshop was realistic in terms of not adding additional content to existing courses. Participants indicated that most school districts struggle to get through their assigned core content and get the students ready for standardized state testing. The workshop allowed engineering and education faculty to collaboratively work on educating the teachers. This made the workshop more effective and realistic in terms of material delivery.

## Acknowledgement

We acknowledge the support of the Martinson Foundation [10] for the ECT program

## References

- [1] [http://www.engineeringk12.org/Engineering in the K-12 Classroom.pdf](http://www.engineeringk12.org/Engineering%20in%20the%20K-12%20Classroom.pdf), Retrieved November 12, 2005.
- [2] Connant, J.B. (1959) The American High School, McGraw-Hill, New York.
- [3] Jahan, K., Marchese, A. J., Hesketh, R. P., Slater, C. S, Schmalzel, J. L., Chandrupatla, T. R. and Dusseau, R. A. (1997), “The Rowan Engineering Program : Preparing Students for the Future Job Market”, Proceedings of the 1997 Zone I Fall Meeting, Wilmington, Delaware, October 1997.
- [4] Jahan, K., Marchese, A. J., Hesketh, R. P., Slater, C. S, Schmalzel, J. L., Chandrupatla, T. R. and Dusseau, R. A. (1998), “Engineering Measurements and Instrumentation for a Freshman Class”, Proceedings of the 1998 ASEE Annual Conference, Seattle, Washington, June 1998.
- [5] Farrell, S., Newell, J. A. and Savelski, M. J., Introducing Chemical Engineering Students to Product Design through the Investigation of Commercial Beer, Accepted for Publication in *CEE*, October 2001.
- [6] Jahan, K. “Water treatment in reverse”, Proceedings of the 1999 Annual Conference of ASEE, Charlotte, North Carolina, June 1999.
- [7] Jahan, K., Tang, Gina and Riddell, William (2005), Teaching Engineering Principles Using an Aquarium, Proceedings of the Mid-Atlantic ASEE Spring Conference, Teaneck, New Jersey.
- [8] [http://users.rowan.edu/%7Ejahan/ECT\\_06\\_08/Ect/index.htm](http://users.rowan.edu/%7Ejahan/ECT_06_08/Ect/index.htm), Retrieved March, 2007.
- [9] <http://bridgecontest.usma.edu/>, Retrieved March, 2007.
- [10] <http://www.edisonventure.com/>, Retrieved March, 2007.
- [11] Jahan, K. and K. Sernak (2007) Engineering Clinics for Teachers, *Proceedings of the 2007 Annual ASEE Conference*, Honolulu, HI.



[12] <http://www.letmelearn.org/>, Retrieved March, 2007.

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