Team Problem Solving Strategies with a Survey of These Methods Used by Faculty Members in Engineering Technology

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ABSTRACT

Students from science, engineering, and technology programs should be able to work together as members of project teams to find solutions to technical problems. The exercise in this paper describes the methods actually used by a project team from a Biomedical Instrumentation Corporation in which scientists, technicians, and engineers from various disciplines participated.

Also described here is a teaching methodology for collaborative problem solving, which includes writing specifications, brainstorming, solution evaluation, sketching, and testing of solutions. In addition, results from the authors' survey on these methods from faculty members who belong to the American Society for Engineering Educators (ASEE), Engineering Technology Division (ETD), are inserted throughout the paper.

While many of these techniques such as brainstorming are common to education majors, many engineering technology faculty have engineering degrees or technology degrees with industrial experience but have not taken any formal teaching methods courses. This survey attempts to find out how widely these techniques are utilized and where faculty received their training.

Students worked together as members of project teams to find solutions to an actual electromechanical design problem using a hematology analyzer from industry. This method can be used in any number of technology and science courses and will help the student prepare for problem solving and working in a team environment.

INTRODUCTION

Competition-anxiety, product-oriented thinking skills, and lack of problem-solving abilities have been identified as problems that inhibit a student's development. When students, at any educational level, work in collaborative groups such as project teams, they have a better chance to explore ideas, justify their opinions, and synthesize knowledge within a supportive environment.[1] This methodology can be used in any discipline.

The following method of problem solving is used by project teams in industry and has been tailored for use in science and technology courses.[2] This activity was presented in an introductory course in Engineering and Engineering Technology to prepare students to work in projects teams in industry and in subsequent courses. Typical three-person lab teams used in Science and Technology were used in this activity which took about two weeks with class periods of about two hours per week.

For this study, the authors designed an eight- question, Likert-type survey which was distributed to faculty who were members of the American Society for Engineering Educators. Faculty members who participated in the survey were asked questions pertaining to each part of the process described.

Survey Question 1. *How often have you incorporated team problem-solving activities into your class assignments?*

	Very Frequently (more than 10 times)	Frequently (more than 5 times)	Seldom (fewer than 5 times)	Never
Associate Degree Engr. Technology	11(52%)	7(33%)	1(5%)	
Baccalaureate Degree Engr. Technology	18(60%)	8(27%)	4(13%)	

Faculty members in both Associate Degree and Baccalaureate Degree Engineering Technology Programs frequently use team problem-solving activities.

THE PROCESS

First, the class divides into project teams with three or four students on each team.[3] Since this was an introductory course with the project of short duration, team members were chosen randomly. Next, for each step of the method, a different person is responsible for taking notes, which will then be distributed to other team members. Each group will submit only one copy of each completed step; the group will decide the division of these tasks. Each student will then be asked to combine the tasks into a report that includes drawings and provide an individual summary page. The components of the report will be as described in the following numbered paragraphs.

Survey Question 2. *How often have you asked students to write culminating reports based on teamwork?*

	Very Frequently (more than 10 times)	Frequently (more than 5 times)	Seldom (fewer than 5 times)	Never
Associate Degree Engr. Technology	10(48%)	4(19%)	5(24%)	2(10%)
Baccalaureate Degree Engr. Technology	10(33%)	11(37%)	6(20%)	3(10%)

More than two thirds of the faculty from both programs very frequently plus frequently require culminating reports based on teamwork.

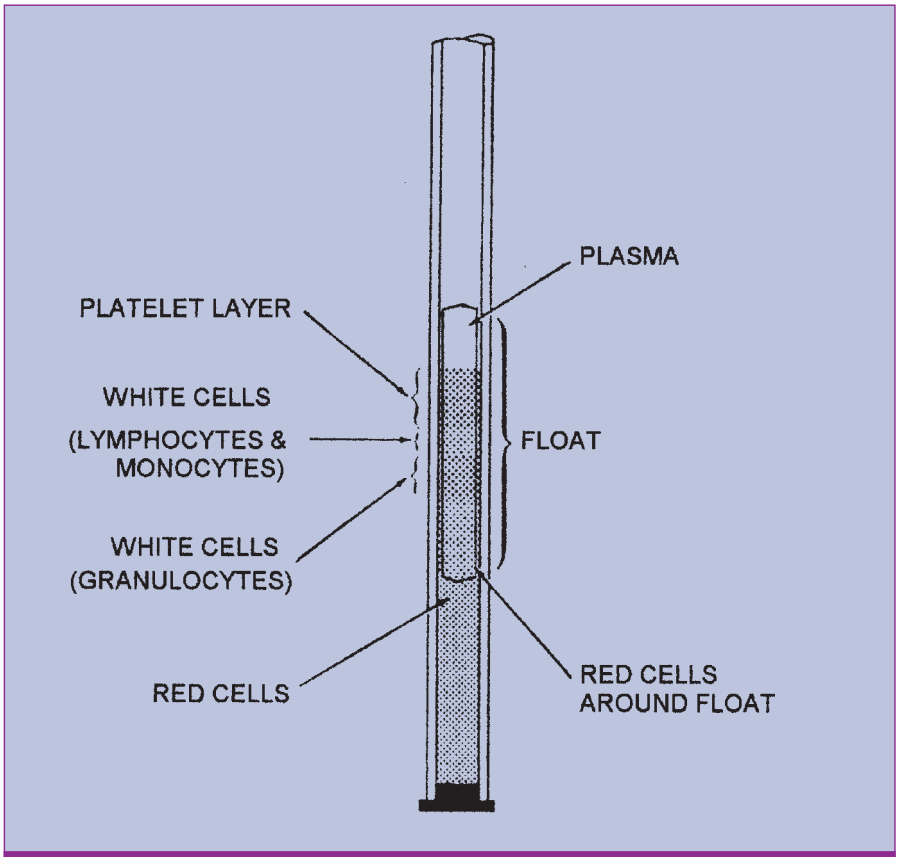

Figure 1. Centrifuged Separated Layers

Activity #1 - Give a Technical Explanation

As an example, an operational explanation of a sample hematology analyzer [3] is provided and a particular technical problem is presented.

For this product, blood is collected from the vein and placed in a hollow tube about 8 cm in length and 2 mm in diameter. A float is inserted into the tube that has the same specific density as the white cells and, thus, expands the white cell band length. The tube is then centrifuged at high speed and settles in layers according to the density of the different components in the blood, as shown in Figure 1. These components consist of red blood cells, white blood cells, platelets, and plasma. The glass tube is coated with special chemicals to accent the color of the different components of the blood. This tube is then placed in an instrument that scans each tube eight times with a laser beam to measure the band lengths and then calculates the value of each of these components in the blood.

The Team Assignment

The objective of the team assignment is for the students to come up with a mechanism for holding this glass tube in place and rotating the tube eight times so that the beam can scan the tube each time.

Activity #2 - Determine the Nature of the Problem and Create Specifications

The teams then ask the instructor several questions in order to help them compile a list of specifications needed to meet the requirements for the given problem.

A sample list of specifications generated by student questions is:

Tube Holder / Rotator Specifications

Tube Rotation Motor

Tube is to be scanned every 45 degrees +/- 5 degrees for a total of eight scans per tube.
All eight of the scans need to be completed within 16 seconds, with the tube being held still for a total time period of one second during each of the eight scans.

Tube Holding Device Specifications

1. Must be able to hold an 80 mm long glass tube with a rubber stopper on one end.
2. The maximum allowable obstruction of the glass tube by the holding device is 3 mm on each end, allowing a length of 74 mm to be scanned.
3. The area between the tube and the laser's optical path must be free of any and all obstructions.
4. The tube must be easy to insert and remove from the instrument without breakage.
5. All tubes have the same dimensions within .03 mm.
6. The tube is allowed to move 1 mm along the axis between each scan. Characteristics of the tube will allow the software to align each scan.
7. There is a rubber stopper at one end of the tube.

Survey Question 3. *How often have you asked your students to write design specifications based on the given parameters of a problem?*

	Very Frequently (more than 10 times)	Frequently (more than 5 times)	Seldom (fewer than 5 times)	Never
Associate Degree Engr. Technology	6(29%)	4(19%)	6(29%)	5(24%)
Baccalaureate Degree Engr. Technology	8(27%)	6(20%)	9(30%)	7(23%)

There was about an equal amount for very frequently plus frequently versus seldom plus never from both programs that asked their students to write design specifications based on the given parameters of a problem.

Activity #3 - Brainstorm to Compile a List of Possible Solutions [4]

A list of ideas created by the team are placed on a chalkboard using the following guidelines:

1. No judgment is passed on any particular idea at this time.
2. Provide as many ideas as possible, even though some of them appear unrealistic.
3. Use a given idea to spark others.
4. Suggest things that actually exist that could be adapted to solve the problem. (Table 1)

Survey Question 4. *How often have you conducted brainstorming sessions in your classes?*				
	Very Frequently (more than 10 times)	Frequently (more than 5 times)	Seldom (fewer than 5 times)	Never
Associate Degree Engr. Technology	6(29%)	7(33%)	5(24%)	3(14%)
Baccalaureate Degree Engr. Technology	10(33%)	9(31%)	9(31%)	1(3%)
Over 60% of faculty from both programs conduct brainstorming session very frequently plus frequently.				

Tube Holding Device		
Slots	Gravity	Tape
Glue	Vacuum	Wheels
Spring Loaded	Rollers	Velcro
Rotisserie	Clamps	Clips
Blood Magnet	Suction	Bands
Static	Fingers	

Table 1. Brainstorming Results

Activity #4 - Research

Students are asked to conduct research to find additional information about the items they suggested during the brainstorming session. In addition, they are asked to look for other common items that may help them add additional items to the list.

Survey Question 5. *How often have you had students look at other sample designs to help them develop their projects?*				
	Very Frequently (more than 10 times)	Frequently (more than 5 times)	Seldom (fewer than 5 times)	Never
Associate Degree Engr. Technology	6(29%)	8(38%)	6(28%)	1(5%)
Baccalaureate Degree Engr. Technology	5(17%)	15(50%)	8(27%)	2(7%)
About 70% of faculty from both programs ask students to look at other sample designs very frequently plus frequently.				

Activity #5 - Select Three Best Possible Solutions

The teams select the criteria for judging the best possible solutions, and then they evaluate and select three of the solutions produced in the brainstorming session. (Table 2)

Optional Activity

These items could be weighted if a more thorough analysis was required.

Tube Holding Device						
		cost	size	availability	life	meets specs
First Choice:	Spring loaded	OK	OK	OK	OK	OK
Second Choice:	Rollers	OK	OK	OK	?	?
Third Choice:	Clamps	OK	?	OK	?	OK

Table 2.. Three Best Possible Solutions (Pro-Con Evaluation)

Survey Question 6. *How often have you taught pro/con evaluations?*				
	Very Frequently (more than 10 times)	Frequently (more than 5 times)	Seldom (fewer than 5 times)	Never
Associate Degree Engr. Technology	5(24%)	3(14%)	6(29%)	7(33%)
Baccalaureate Degree Engr. Technology	8(27%)	4(13%)	8(27%)	9(30%)
About 40% of faculty from both programs have pro/con evaluation very frequently plus frequently.				

Survey Question 7. *How often have you taught weighted techniques in decision making?*				
	Very Frequently (more than 10 times)	Frequently (more than 5 times)	Seldom (fewer than 5 times)	Never
Associate Degree Engr. Technology	3(14%)	5(24%)	5(24%)	8(38%)
Baccalaureate Degree Engr. Technology	5(17%)	10(33%)	5(17%)	10(33%)
About 38% of faculty teaching in Associate Degree Programs have taught weighted techniques in decision making very frequently plus frequently while 50% in Baccalaureate Engineering Technology Programs.				

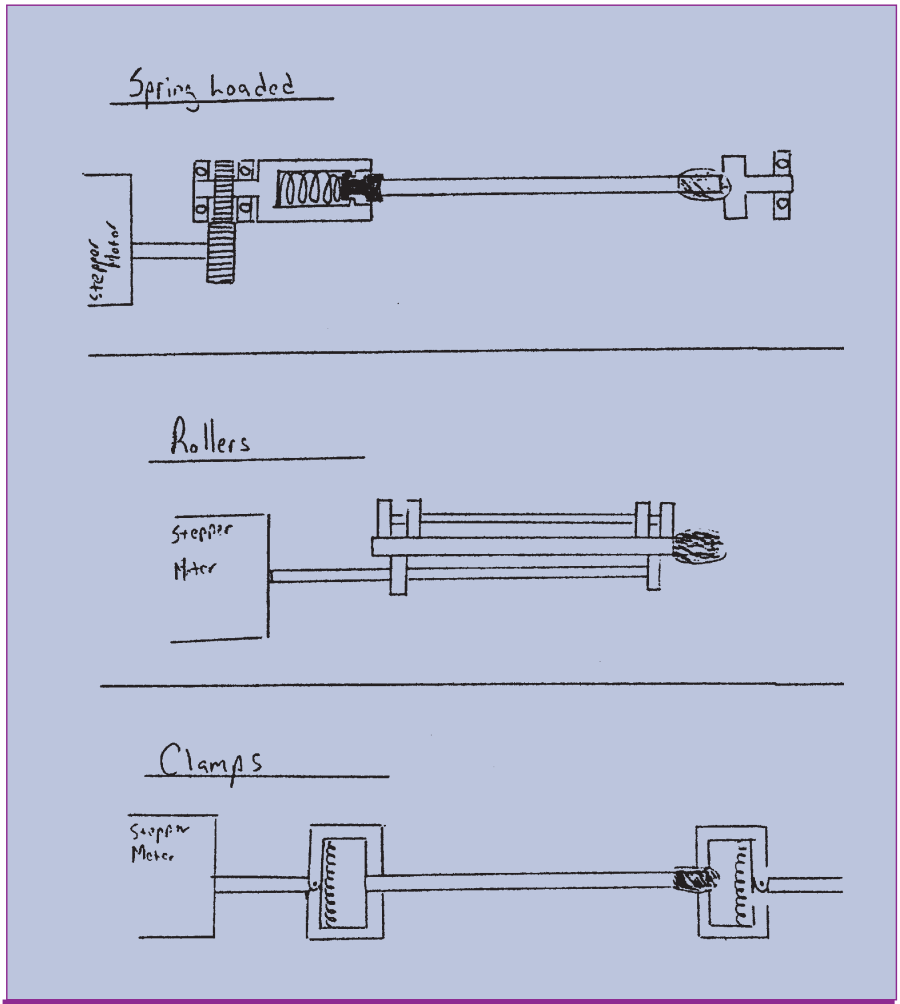

Figure 2. Copy of Student Rough Sketches

Student Comment

This is a comment taken from one of the student reports for the example described in this paper:

Student Comment -"During the pro-con evaluation of the tube holding device we concluded that the spring-loaded device would easily meet all of our needs and also would be easy to manufacture in-house. We had some doubts as to whether the rollers would meet our limited obstruction requirements and also felt that clamps could not be sized small enough to fit our design or meet life requirements."

Activity #6 - Produce Rough Sketches

A rough sketch completed in class of each selected solution is produced and are shown in Figure 2.

Activity #7 - Solution Testing

A list of possible ways to conduct tests on each solution is generated.

Testing the Design

Some of the possible methods to test the design include:

1. Rotate the tube and check to see if it scans every 45 degrees. After eight scans, the tube should be back at its starting point.
2. Scan empty tube with no markings to verify no obstructions.
3. Have many people insert a large number of tubes in the instrument to test ease of use and no breakage.

Survey Question 8. *How often have you discussed how to test solutions to problems?*

	Very Frequently (more than 10 times)	Frequently (more than 5 times)	Seldom (fewer than 5 times)	Never
Associate Degree Engr. Technology	7(33%)	3(14%)	7(33%)	4(19%)
Baccalaureate Degree Engr. Technology	12(40%)	9(33%)	4(13%)	4(13%)

About 50% of faculty teaching in Associate Degree Programs have discussed how to test solutions to problems very frequently plus frequently while this is done 73% in Baccalaureate Engineering Technology Programs.

Additional Activity

If this was more than an introductory course and more time was allocated for the topic, the students could be asked to make prototypes to test their solutions to the problem.

Survey Question 9. *Where did you receive training in teaching methodology? (multiple responses)*

Number of Responses	Place of training in teaching methodology.
32(48%)	Self taught or on the job training
15(22%)	Seminars, conferences, or workshops
6(9%)	Short courses
5(8%)	Degree in Education
5(8%)	Undergraduate education courses
2(3%)	Graduate education courses
2(3%)	Journal Articles

While faculty members have degrees in their discipline and industrial experience, most received their training in teaching methodology that was self-taught and on the job training or through seminars, conferences, and workshops.

DIFFERENCE BETWEEN ENGINEERING AND ENGINEERING TECHNOLOGY

According to the American Society for Engineering Educators (ASEE's) Engineering Technology Council (ETC)[6]:

"Engineering" is the profession in which a knowledge of advanced mathematical and natural sciences gained by higher education, experience, and practice is devoted to the creation of new technology for the benefit of humanity. Engineering education for the professional focuses primarily on the conceptual and theoretical aspects of science and engineering aimed at preparing graduates for the practice of engineering closest to the research, development, and conceptual design functions.

"Engineering Technology" is the profession in which a knowledge of the applied mathematical and natural sciences gained by higher education, experience, and practice is devoted to application of engineering principles and the implementation of technological advances for the benefit of humanity. Engineering Technology education for the professional focuses primarily on analyzing, applying, implementing and improving existing technologies and is aimed at preparing graduates for the practice of engineering closest to the product improvement, manufacturing, and engineering operational functions.

CONCLUSION

Content information and effective instruction (pedagogy) are critical components of learning. When both are emphasized, the students learn the subject matter AND the habits and strategies to be successful learners.

As a Senior Project Engineer with 14 years of experience in industry managing project teams consisting of other engineers, scientists, and technicians, finding new people to hire with project team experience was important. Historically, solutions produced by student teams have been quite similar to those of actual industrial project teams. Students write papers based on the team project, which could be reviewed or presented to a local industrial advisory board. These reports were used as sample material of active and collaborative learning during an Accreditation Board for Engineering and Technology (ABET)[7] re-accredidation visit. Faculty members should be able to present this same team project to their class using the information from this paper or use their own topic and just follow the methodology.

Of the twelve faculty members that received training in teaching methodology from formal undergraduate education courses, or received an undergraduate or graduate degree in education, ten answered either "very frequently" or "frequently" to almost all of the eight questions.

Notes

1. Adams, d. & Hamm, M. (1998). Collaborative Inquiry in Science, Math, and Technology.

2. Demarco, T., "Productive Projects and Teams," Dorset House Publishing, NY, 1999.

3. Barra, R., "Tips and Techniques for Team Effectiveness," Barra International, New Oxford, PA, 1993.

4. Carr, J.," Introduction to Biomedical Equipment Techno-logy," 2nd ed., Prentice Hall 1993. P. 357

5. Osborn, A., "Applied Imagination.," Creative Education Foundation Press, Third revised edition, 1993. pp. 166-182.

6. http://www.asee.org

7. http://www.abet.org

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Dixie L. Winters is an Instructor of Education in the Focused Masters Degree Program in Teaching and Curriculum at the Penn State University York Campus. Her research interests include practitioner research and pedagogy. Dr. Winters was a Language Arts Program Coordinator and teacher in public schools for numerous years. She earned B.S. and M.S. Degrees in Secondary English from Millersville University (PA) and a Doctorate of Education from Temple University (PA). Currently she is president of the Lancaster-Lebanon Reading Council and a member of the Executive Board of the Southern Region Pennsylvania Association of Supervision and Curriculum Development. Dr. Winters is an expert in the development of oral communications skills and is completing a book on that topic.