AC 2012-3636: AEROSPACE ENGINEERING IS STILL COOL: ACTIVE LEARNING, EFFECTIVE TEACHING TECHNIQUES

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Aerospace Engineering is still cool - Active Learning, Effective Teaching Techniques

Abstract

Active learning techniques have been studied and applied successfully in various disciplines. These techniques encourage students to stay interested and engaged in the courses. Just like any other engineering discipline, such techniques are often necessary in aerospace engineering classes. In this paper, we explore various student centered, active learning, and teaching techniques in various disciplines and investigate their feasibility for implementation in aerospace engineering.

Key Words: Active Learning, Student Centered, Teaching Techniques

Introduction

The focus of this research is to identify a few key students centered active learning techniques that are applicable in core aerospace engineering classes. Aerospace engineering, although attracts some of the brightest minds, is still a demanding and hard discipline to study. Most of the students who enter the discipline do it because they are interested and get fascinated by flying objects. Yet, at some of the major universities across the country, the dropout rate in the undergraduate aerospace engineering classes is higher than other disciplines [19]. Besides the discipline being hard to understand and study, another reason that high dropout rate can be attributed to is the lack of student centered active learning techniques used in the aerospace engineering classes. In this paper, the author investigates some of the techniques and methodologies used in other engineering and especially non-engineering disciplines that can be borrowed and applied to aerospace engineering. There have been numerous efforts in various disciplines where college and university professors have been challenged to develop instructional methods that transform students from passive listeners to active learners [1]. In the author's experience, introducing such techniques in a highly conceptual and mathematically intensive aerospace class is 'easier said than done.'

Active learning is in short, anything that students do in a classroom other than merely passively listening to an instructor's lecture. This includes everything from listening practices which help students to absorb what they hear, to short writing exercises in which students react to lecture material, to complex group exercises in which students apply course material to 'real life' situations and / or to new problems [2]. Some of the active learning techniques explored in this research include brainstorming, think-pair-share, thumbs up / thumbs down response to statement, pause procedure, group discussions, guided lectures, students work a problem then evaluate each other's work, responsive lectures, use of props, muddiest point, puzzles / paradoxes, discussions, work on the blackboard, games etc.

Active Learning

Active learning is anything course-related that all students in a class session are called upon to do other than simply watching, listening and taking notes [3]. Active learning is done in a class when the instructor asks a question, poses a problem, or issues some other type of challenge. While teaching the Prandtl's lifting line theory in the undergraduate low speed aerodynamics class, instead of showing slides or drawing the horseshoe vortex on the board and giving long lectures about it, the instructor briefly tells the students the basic concept, background, and example uses. The instructor then tells students to work individually or in small groups to come up with examples of scenarios where such a model could be used. Some time is given to students to work on this, they are then stopped and the instructor then calls on one or more individuals or groups to share their responses.

The instructor is not doing active learning when they lecture, ask questions that the same few students always answer, or conduct discussions that engage only a small fraction of the class. Aerospace engineering can be taught using inquiry based approaches [4, 7]. Instructors need to spend part of the class time teaching students what they know, explaining, clarifying, demonstrating, and modeling etc. But active learning entails avoiding making lecturing the only thing the instructor does in the class. If a lecture or recitation session includes even a few minutes of relevant activity, the students will be awake in a way that never happens in a traditional lecture. Most students will retain far more of what happens in those few minutes than what the instructor says or does in the rest of the session. If the instructor does this in every session of every course they teach, at the end of the semester, they will see the evidence of the high level learning [4].

Involving Students in Aerospace Engineering Classes

The idea of active learning is to get students involved. Students could be involved in a variety of ways in the class. For a part of the class, instructors steps off the stage and lets the students run the show. Instructor could ask the students to explain what they think aerospace engineering is. Depending on the responses that the instructor gets, they can fill in the blanks. Students could be asked collectively to define the various lifecycle phases of a product. Students could be asked to approach the board and write their answers. This will get all the students actively involved in the class. Inevitably they will miss a few items. The instructor can then step in and complete the desired flow chart. This approach may take only a few minutes but the active involvement of students will increase the chances of them retaining the desired material. It also reduces the instructor's workload.

In the aerospace core classes e.g. aerodynamics, aircraft performance, propulsion, acoustics, structures, etc., which are based on problem solving, the instructor can give students small problems during class, or can have them come up with problems and formulate them. This could be done in small groups or as a whole class depending on the size of the class. Students learn tremendously when they actively participate in problem formulation and solution. In the aircraft design, senior design, or introductory astronautics class, case studies could be used to give real world examples. Case studies work equally well for graduate and undergraduate students. There are a number of other active learning methods that could effectively be used in aerospace

engineering classes. Some techniques successfully used by the author are described in detail as follows.

Project Based Teaching

In the author's experience, students have always indicated that they learnt more from doing projects in undergraduate aerospace analysis and design class than anything else. Project based learning begins with an assignment to carry out one or more tasks that leads to the production of a final product. The final product could be a design, a model, a device or a computer simulation. The work done on the project is normally presented in the class and a written report is submitted. Students are required to summarize the procedure used to produce the product and represent the output. There are usually two projects given in the class. The first project is defined by the instructor, which helps maintain a focus on course and curriculum objectives. In the second project, students are allowed to pick their own topic, which gives them the autonomy to choose their own project formulations and strategies, which in turn increases their motivation. Some of the past students projects include designing and building of wind tunnel models, 3-D aerospace models, variable pitch thrust measurement apparatus, flight simulation frame, water tunnel etc. All of these products become part of the aerospace laboratory to be used by future students.

Project based learning at the individual course level is familiar in engineering education. It is used almost universally in capstone design and laboratory courses. There has been growing frequency of project based learning approach in first year engineering courses and courses that engage students in consulting projects [5, 7]. Because of its effectiveness, project based learning can be made the focus of teaching in many aerospace engineering courses.

Case Based Teaching

Cases are shorter than projects. Often one or more cases can be covered in one class session. Most of the aerospace engineering courses can be taught using cases. In case-based teaching, students analyze case studies of real world or hypothetical situations. These cases may involve problem solving or decision making – both of which are important ideas to teach aerospace engineering students. In the context of engineering education, a case has been defined as '*…an account of an engineering activity, event or problem containing some of the background and complexities actually encountered by an engineer*' [5]. Similar definitions apply to other disciplines like law, arts, music, management, teacher education, or any other fields that have made extensive use of cases for professional training.

Teaching with cases often involves several challenges for the instructor. These include diagnosing technical problems and formulating solution strategies, making engineering and management decisions taking into account technical, economic, and social and psychological considerations, and confronting ethical dilemmas [6]. The instructor needs to either have lots of experience or they can invite aerospace engineers from the industry to give seminars and present cases. The instructor can then have students analyze the cases. The cases need to be authentic, and may also be drawn from stories in the newspapers or magazines or built from interviews with individuals involved in the situations in question. At the author's home institution, one of the aerospace engineering professors teaches his human factor course exclusively from cases. He

works as an expert witness in courts and therefore has lots of real world cases to discuss in class. A case might include descriptions of what happened and what led up to it, the problems and challenges, the resources and constraints under which solutions could be sought, the decisions that were made, the actions that were taken, and the outcomes. A National Transportation and Safety Board (NTSB) crash scene investigation representative may be a great resource to work with for determining good cases. All aviation incidents and accident are documented by NTSB and are available in public domain.

Engineering students get excited when they are presented with a real world problem that needs to be solved. When an engineering student is challenged with a problem, they get motivated to solve it. The idea is that in analyzing complex authentic cases, students become aware of the kinds of situations and dilemmas they might have to face as professionals. This helps them gain both theoretical and practical understanding of their subjects and develop critical reasoning skills.

Just In Time (JIT) Teaching

Just in time is an engineering concept derived from the production strategy. Just in time approach strives to improve a business return on investment by reducing in-process inventory and associated carrying costs. Just in time teaching combines Web-based technology with active learning methods in the classroom [5, 6]. Students individually complete web-based assignments a few hours before class in which they answer questions, and the instructor reads through their answers before class and adjusts the lessons accordingly, 'just in time.' This process is repeated several times a week. The use of questions to drive learning makes the method inductive. The technique can be combined with almost any in-class active learning approach. The just in time teaching resources include enrichment materials of several types including course related news stories, on-line homework, and various computer based mechanisms for communication between students and the instructor [5, 7].

Teaching Methods Used in Other Disciplines

The author is part of a Research Learning Community (RLC) at their home institution. The purpose of the RLC is to provide a platform to the instructors from various disciplines where they can share ideas and techniques used to get students involved actively in the classroom. The RLC members come from engineering, mathematics, languages, arts, music, and law. A brief list of active learning techniques and their explanations used in these disciplines is as follows.

Engineering:

Following list of active learning techniques works well for engineering students [8].

1. *The muddiest point* – Students are asked about the concept they did not understand in a class and then the instructor goes over it again at the end of the class.
2. *True False questions* – Students are asked to answer T/F questions during class. This serves better than quizzes because they learn while being assessed. They are given participation points.

3. *Use of props* – Students get engaged when they can see or touch an object or a model.
4. *Candy questions* - Students get a reward for actively participating in the class. Every once in a while, a hard question is asked. The first person to answer the question gets a candy. This motivates students and encourages active classroom participation.
5. *Mind break* - The instructor talks about something completely off-topic for a few moments e.g. in a propulsion class, the instructor will ask about the capital city of Canada.
6. *Pause Procedure* – The instructor pauses periodically and have students clarify their notes with a partner. This can be done two or three times during an hour long class. Because of its simplicity, the pause procedure provides a baseline to study whether short, informal student activities can improve the effectiveness of lectures. Ruhl et al. show some significant results of adopting this procedure [4, 18].
7. *News Share* – Students are asked to share the latest news about certain technology. Students are eager to speak and tell everyone what they saw. Sometimes they pull up the news on their hand held devices so they can discuss it in class.
8. *Hand Raise* – Students are asked to raise their hands after about 20-30 minutes of lecturing. This helps them focus again on the topic of discussion in class.
9. *Book Ends* – Students are asked to present to the class in 3-4 minutes the summary of the previous lecture. Students take turn in every class so everyone in class gets a chance to present. Students can be given some credit for presenting/summarizing the lectures.
10. *Think-Pair-Share* – The instructor poses the problem. Students are asked to work on it individually for a short time. They are then asked to form pairs and collaborate and improve their solutions. The instructor then calls on several individuals or pairs to share their responses. This structure takes a bit more time than a simple group activity, but it includes individual thinking and so leads to greater learning [3].
11. *Brainstorming* – The instructor presents a concept or a group of concepts to students at the beginning of the class. The students work in small groups to brainstorm and possibly organize past experiences that may relate to the class objective for the day [1].
12. *Thumbs up, Thumbs down* – The instructor makes a statement about the content and tells students to put their thumbs up if they agree with the statement – thumbs down if they disagree or thumbs sideways if they don't know [1].

Cooperative learning techniques have also been utilized in engineering classroom environments with some success [9, 10]. Cooperative learning is an instructional approach in which students work in groups on a learning task. The 5 essential elements required for implementing a cooperative learning technique in an engineering classroom are [11]: positive independence, individual accountability, face-to-face interaction, appropriate use of interpersonal and teamwork skills and regular self-assessment of team functioning. The RLC is composed of other disciplines. In addition to the above techniques, instructors in other disciplines have successfully employed a number of other active learning techniques. Some of the disciplines and the techniques used in them are listed as follows.

Law

Active and Cooperative Learning techniques have proven to be advantageous for the law classes. Some of these techniques are equally advantageous in the aerospace engineering classes. Like

other disciplines, it is necessary for the law faculty to think outside of the traditional legal education "box" and use some active learning techniques to keep undergraduate students engaged. Following are active learning techniques that have been used in undergraduate law courses across disciplines and are applicable to aerospace engineering classes:

1. *Mock Trials* – Students are assigned various roles (attorneys, witnesses, jurors, etc.) and act out in a complete trial starting with jury selection and proceeding all the way to a verdict. A professor at the author's home institution teaches an entire human factor engineering course based on cases and mock trials.
2. *Mini-Case Studies* – In this method, the instructor spends a minimum amount of time lecturing in class and most of the class period actively engaging students in case studies. The instructor breaks the class into groups and presents a fictional legal scenario demonstrating a legal problem. The groups discuss and then present 1) the facts of the fictional case, 2) the applicable law, 3) an analysis of the problem and finally, 4) a conclusion. Good and bad aircraft designs can be criticized using a similar technique.
3. *The Socratic Method* – Often used in law school, this method forces students to be engaged and "on their toes." In this method, the instructor calls on students at random and asks them questions about the material (regardless of whether the instructor has lectured on that material yet). Should that particular student not know the answer (or sometimes even if they do), the instructor calls on another student to verify or challenge the first student's answer. At the risk of being embarrassed or proven wrong, students are forced to be prepared for class. Students are given points for correct answers preparedness.
4. *Student polling* (Use of "Clicker Systems") – Throughout the lecture, the instructor asks survey-style questions and students answer the questions using hand held clickers. Results display on the screen anonymously. This gives the classroom more or a game-feel and keeps students engaged. Typical clicker technology interfaces with Microsoft PowerPoint, so instructors are generally able to use their existing lecture content.
5. *Student-Generated Content* – Making students responsible for the content to be learned is a frequently used technique. This can take many forms including:
    - Exam questions (Have students generate 5 exam questions based on the material for that day/week)
    - Student-led discussions (Have 1-2 students in each class come prepared with 2-3 discussion questions and lead the class in a discussion based on the material for that day/week)
    - Student-led classroom activities (Have 1-2 students come to class prepared to lead their classmates in a 30-minute activity that demonstrates the material covered that day/week).
6. *Debates* – Students divided into groups are given two opposite sides of an issue and allowed to make an argument for their position. The opposing side is given a chance to respond to arguments made and a lively discussion ensues. An example in the introduction to aerospace class could be the argument about the closing of NASA space shuttle program or whether it is wise to spend any more U.S. tax payer money on the International Space Station (ISS).

7. *Game-based learning* – In this technique games are used to demonstrate concepts to students. The games can be as simple as Jeopardy or as complex as video/computer games.

Languages

There are numerous active learning techniques employed in foreign or world language classes that could be used in aerospace engineering classes. In order to implement these techniques educators must be aware of 6 areas of skills acquisition in their students—especially in the introductory and intermediate levels of study. These areas are listening comprehension, speaking, reading, writing, culture, and grammar. In order to learn or acquire a second language (L2), a student must be active [12]. The instructor must create situations by which the student will respond as comfortably as possible, with as little fear of making a mistake in public. The instructor must move that student from the mechanical, to the meaningful, and finally to the communicative level of activity, wherein they are completely free of the instructor, and truly independent.

Following are some techniques to help the student arrive at this point of ownership of the material [13, 14]:

- Classroom management
- Repetition of material
- Active participation regarding listening and speaking (without seeing the written words)
- Writing independently with student ownership rather than teacher dependence
- Practicing and rehearsing cultural norms

Specific strategies and explanations for use of the techniques listed above include:

1. *Circular Seating Arrangement* - The class seating arrangement is circular, so students are encouraged to talk to one another. The teacher is not the focal point of the class. The class arrangement will change within the class period and between one class period and the following one. The teacher's role is now that of the class facilitator.
2. *Dialogue* - The instructor moves from repetition of a new concept, to directed dialogue, and finally to free use of the new concept, withdrawing from the role of animateur. The instructor can have choral work, small group work, and finally individual work in order to reduce anxiety levels. Engineering concepts can often be taught effectively by engaging students in a dialogue.
3. *Speaking and Writing* - Just as listening comprehension and reading are, on the surface at least, passive skills, speaking and writing are active. The technique used for listening comprehension moves from mechanical, to meaningful to communicative, i.e., independent comprehension. With respect to writing, current pedagogical trends take the emphasis off the final product, seen only by the instructor (a dependency), and places it on the student and their peers (independence). The emphasis in writing is on the process or development of the piece, whereby the student controls the various versions, not the instructor.

4. *Use the tools* – In languages the best way to learn is to continue to use it. Several tools are taught in aerospace engineering classes. The best way to learn and retain them is to use them. Again, the instructor is there pointing the way, and the student has to gather up the courage to go places theretofore unknown. They learn how to think about the engineering tools not from memorized rules, but through their use.

Arts

There are many activities that are used with art appreciation/visual art classes to engage students in active and cooperative learning. These approaches go beyond traditional lectures typical of Art History classes. Students in art appreciation classes consider the visual arts from multiple perspectives including concepts, interrelationships and relevance to different disciplines and with everyday life. Many strategies support and reinforce critical thinking that is essential to all disciplines including aerospace engineering.

The following examples illustrate some of the active and cooperative learning techniques [15].

1. *Affective Response* - provides an emotional or evaluative response to material. Students look at works of art and note the reaction/response they have to the image/artwork. They reflect on what they see and what has been discussed regarding the components of a work of art the Elements of Art and the Principles of Design. They consider other information such as how colors have symbolic meaning as well as have psychological effects on individuals.

   In arts, students consider the work of art in the context of the time it was made vs. how it may be perceived today. Discussions in class consider what we know, and how we learned or acquired the information. Students evaluate how connections, associations, or summations are made and how that may be reflected in the way we view art. Students may work alone (active learning) and/or in small groups (cooperative learning). This technique could be used in aerospace engineering where students are encouraged to think critically and critique the contents taught.

2. *Puzzles & Paradoxes* - Students become familiar with a topic, concept, etc. through activities in and outside class. These include research, videos and reading (articles, newspapers, online). Students discuss issues and defend their opinions. Factors for students to consider include current events such as a country's economic stability. In 2011 this was the debt crisis in Greece. These are then discussed in class using puzzles and paradoxes. This technique could work well in engineering economics or other quantitative classes.

3. *Evaluation of another students work* - Students create a variation of an art in a visual design that represents them, using symbols and images. In class students in pairs or small groups review the original sketches of the other students. Positive feedback on the symbols and composition is given and then considered when the final version is made. The final version is also reviewed in class and pairs of students write out their comments on the finished work regarding "readability", referencing such aspects as symbolism and

composition. The instructor considers the comments in grading. Evaluation of other student work can also be done in projects, presentations etc.

4. *Visual Lists* – This entails the literal looking at art images and comparing them for various aspects. One example is comparing ancient Egyptian and Greek sculptures. This is analogous to comparing various aerospace engineering models.

5. *Games* - Modifying games such as Jeopardy and Bingo are ways to engage teams or the entire class in reviewing lectures for the class. Students respond to the aspect of competition and can become very engaged [16].

Music

Arts teachers continually reiterate the importance and value of the arts in the lives of students. To make aerospace engineering interesting, the instructor needs to find and use examples of the implementation of aerospace engineering in real world applications. Learning objectives in music classes include becoming consumers of "good art." This is contingent upon students having broader listening skills and an extended music vocabulary to express what is heard within the music; and the ability to express individual preferences for music. These skills can aid engineering students with the ability to make educated judgments. This encourages expectation that they continually seek the aesthetic experience that engineering education provides.

Effective techniques for active learning in music courses that can be used in aerospace engineering courses are:

1. *Music Presentations* - Each class begins with an assigned student presenting a personally-chosen musical selection of any genre. As the class listens to this selection, they must list ten "things" heard within the piece which increases the students' aural skills and musical vocabulary. At the conclusion of the piece, the assigned student reads the ten reasons why it was selected for presentation. Similar exercise can get engineering students introduced to other student presentation topic and can trigger intelligent conversations that can lead to long term retention.
2. *Building Blocks* - Students are introduced to the two "systems" of music (pitch and rhythm) and the basic language of music. Students are taught how individual pitches are able to create triads and how triads relate to a "whole" [piece of music] through the study of Roman Numeral Analysis (I, IV, V7). Students are asked to associate this concept of an individual pitch; chord; whole relationship; to a concept within their own major and submit their written answers and drawings. Building blocks can be used very effectively in engineering classes e.g. when discussing the evolutionary process model.
3. *Concert Attendance* - Students are required to attend two symphonic or band concerts and write a report on each concert detailing all musical selections and aesthetic experiences. These reports incorporate music vocabulary; the recounting of what was heard in each piece; and explanations to support why selections of music were or were not preferred. Written reports get students consciously thinking about the music (melody, harmony, rhythm, patterns, instrumentation, orchestration, dynamics, etc.) and how these individual concepts combine together to create a larger essence. The concert attendance requirement

gets students to attend an event outside a comfort zone and provides the 'stepping-stones' for future attendance. Analogous to a concert in music, an engineering student can attend a technical conference, seminar, or a workshop and asked to present and summarize in writing their takeaway points based on pre-defined learning objectives.

4. *Transformative Assessment* - Each student is given three different colored folders or cups (red: not understanding; yellow: slight understanding; and green: full understanding.) While instructing, the teacher is able to view each of the student and the colored folder they have placed in front of them. Without causing embarrassment or disrupting the class, it is known which student understands in the moment. Students may also change their folder colors anytime during the lecture. The instructor is able to assess one's own teaching in the moment and change it to accommodate the student or class. This assessment technique relaxes the classroom climate and works especially well during music theory instruction. Another teaching technique employed is the use of colored chalk during lectures which assists students in correlating the information written on the board.

Through the study of music, students' aural skill awareness is heightened; music vocabulary and the basic language of music understanding are increased. Confidence in attending arts events is gained. The ability to make informed and educated decisions about music is acquired. These techniques are analogous to aerospace engineering students attending a disciplinary technical seminar, workshops, or conference, with a pre-defined set of learning objectives.

Correlation of Active Learning Techniques across Disciplines

The active learning techniques discussed are inspired from a variety of disciplines including mathematics, languages, arts, and law. All of these well-established disciplines have matured the art of actively engaging students in and outside of classrooms for effective teaching and learning. The techniques mentioned in this paper are a sample of a variety of techniques used. A number of them can be modified and used in aerospace engineering classes. This will help generate student's interest in the classes at the undergraduate level, where they may not fully appreciate the value of learning the contents. As aerospace engineering discipline grows and becomes more popular, this approach may also encourage other students to join the field at the undergraduate level. Few of the techniques are summarized and compared across disciplines in Table 1 [17].

Table 1: *Comparison of active learning techniques across disciplines*

	Engineering	Mathematics	Languages	Arts	Law	Music
Muddiest Point / Clarification Pause	X	X	X			X
Group Quizzes	X	X	X			
Use of Props	X		X			
Incentives (Candy Questions)	X		X			

Mind Breaks	X		X			X
Ownership of class	X		X			
Wait Time	X	X				X
Evaluate each other's work		X	X	X		X
Cooperative Groups	X	X	X			
Games		X	X	X	X	
Student Generated Content		X	X		X	X
Changing Seating arrangement			X			
Problem Solving / Writing		X	X			X
Puzzles / Paradoxes				X	X	
Student Polling			X		X	
Debates			X		X	

The effective teaching techniques are mapped across disciplines to qualitatively explore and identify which techniques work best in general for aerospace engineering undergraduate students.

Obstacles and Barriers for Active Learning Techniques

Several faculty members, especially in the engineering fields claim that they cannot apply the active learning techniques in their classes. Bonwell [1] summarizes the obstacles and barriers that prevent faculty from using active learning techniques in their classes. Some of the common obstacles and their remedies are listed in Table 2.

Table 2: Obstacles to active learning approaches and their solutions

Obstacle	How to overcome the Obstacles
Cannot cover as much course content in the time available	Find other ways to ensure that students learn assigned course content e.g. using assignments, in-class exams etc.
Devising active learning strategies takes too much pre-class preparation	It will not take any more time than that needed to create thorough and thoughtful lectures

Large class sizes prevent implementation of active learning strategies	Some techniques work well for large classes e.g. small group discussions, students critiquing other student's work etc.
Most instructors see themselves as being good lecturers	Teaching does not equal learning. This can be seen in the student performance in the examination papers.
There is lack of material or equipment needed to support active learning approaches	Some strategies do not require any equipment e.g. asking students to summarize the material they have learnt, form pairs to evaluate statements etc.
Students resist non-lecture approaches	With explicit instruction in how to actively participate and learn in less traditional modes, students soon come to favor the new approaches

All of the barriers and obstacles listed in Table 2 are applicable in aerospace engineering undergraduate classes. In the author's opinion, the biggest change that needs to happen to incorporate active learning approaches in classes is the openness of the faculty member to the idea that these approaches will result in better learning and retention for students.

Conclusion

In this paper, the low and high risk active learning strategies, specific to aerospace engineering classes are explored. The importance of active learning is emphasized. Some of the obstacles and barriers that prevent faculty from using active learning strategies are discovered and their remedies are explored. Several effective active learning techniques, as used in other, especially non-engineering disciplines, are explored. Techniques that could effectively be used in aerospace engineering classes are explored. In addition to project based, Just in Time and case based teaching, some of the other techniques include the group quizzes, games, student generated content, group problem solving, polling, debates etc. Not all techniques work for all aerospace engineering classes. The aerospace engineering instructor needs select a few in some classes and try others in the other classes. The effectiveness of these may vary depending on the course contents and objectives. These techniques, when used with due preparation, are expected to keep the field of aerospace engineering cool, keep students interested in the field, and produce better results than traditional deductive style of teaching.

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