AC 2011-1252: TECHNIQUES FROM WORKSHOPS ON TEACHING: IMPLEMENTING THE CONCEPTS AND EVALUATING OUR APPROACHES

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Techniques from Workshops on Teaching: Implementing the Concepts and Evaluating Our Approaches

Abstract

The challenges for new engineering educators abound and there are never enough hours in a day or days in a week. Young educators may lack confidence in course subject material given that they have never taught (the topic and/or in a classroom) before. In addition, their knowledge of teaching pedagogy and classroom management strategies often lacks refinement since their education is almost exclusively in a field of engineering rather than education. Teaching workshops have been developed to expose instructors in higher education to practical teaching pedagogy and effective classroom management. These workshops often emphasize research-based methods including use of clearly defined learning objectives and implementing active learning techniques in the classroom. Such methods can be very useful and have been shown to be successful; however, for the new engineering educator, the implementation of such methods can be mentally and emotionally challenging and time consuming.

This paper provides the authors' reflection, as two relatively new engineering educators, on their personal implementation of learning objectives and active learning techniques in the classroom in their second and third years of teaching. We feel that our comparative evaluations are unique and helpful because we teach at two different teaching-focused institutions and have employed methods and techniques that we have gleaned from attending two different, unrelated workshops. While both workshops promoted active learning techniques, one workshop was geared primarily towards engineering education and included topics on developing appropriate learning objectives while the other workshop was multidisciplinary with attendees from the humanities and the sciences and focused primarily on active learning in the classroom.

Both of the authors found their respective workshops to be very beneficial, both have endeavored to incorporate techniques from these workshops, and both have had success and struggles in the implementation of these methods. One aspect discussed is the development of learning objectives which drives lecture content and enables students to review their own mastery of the material. In addition, a specific active-learning technique that has been implemented by one of the authors in an engineering course is presented in depth. The approach involves working on a conceptually-focused quiz problem through individual work, group work, and class discussion throughout a class period. This method motivates the students to engage, discuss, and learn together actively as they work cooperatively with a unified focus.

This reflection of the specific approaches to integrating appropriate learning objectives and active learning techniques into our engineering courses can provide concurrent perspective for other new engineering educators seeking to improve their effectiveness in the classroom and experienced educators looking for fresh ways to engage students. As a result of the authors' experiences and reflection, a collection of tips for success in implementing specific teaching strategies is provided.

Introduction

The requirements on a new engineering educator's time are many and varied. In addition to providing a fantastic learning environment for future engineers, the instructor may be asked to define a scholarship avenue, write grants, and serve various entities within and outside the university all the while with tenure looming. With all these demands on the new instructor, time outside of work is extremely limited. Clearly, time management skills are required to be successful, but a firm grasp on how and when to do a task provides traction for rapid and responsive fulfillment of the objectives for completion. As the education model currently stands, most engineering educators have limited experience at educating prior to their first day at "the front" of the classroom. Their knowledge of teaching pedagogy and classroom management strategies often lacks refinement since their education is almost exclusively in a field of engineering rather than education. In addition, these "young" educators may lack confidence in course subject material given that they have never taught (the topic and/or in a classroom) before. Clearly, the subject material must be understood in order to develop learning environments where students can gain knowledge and skills. Yet, even the description of developing a learning environment points to the need for, at least, understanding or, at most, mastery of teaching principles and methods of application.

While arguments could be made for requirements of additional education for future higher-education instructors (just as most states require Master degrees of P-12 educators) or integration of education principles and modes of application into existing technical/engineering graduate programs, this paper will focus on the existing structure and how two young (in both senses of the word) educators were able to extend their knowledge of educational principles and rapidly improve their in-class learning environments.

Background

The development of teaching workshops has occurred at the university, regional, and national levels; the focus of the material presented in these workshops can apply to a specific area (e.g., engineering) or can provide universal principles with examples of implementation in various subject areas. With workshop times being either short with various meetings throughout the term/year or concentrated periods of eight hour days for 1–5 days, education experts expose both new and seasoned instructors to practical teaching pedagogy and effective classroom management. These workshops often emphasize research-based methods including use of clearly defined learning objectives and implementing active learning techniques in the classroom. The authors each attended a teaching workshop in summer 2009, but the workshops had distinct differences.

Known to many in the ASEE, the National Effective Teaching Institute (NETI) has convened Thursday–Saturday prior to the ASEE Annual Conference since 1991.[1] The application of the material is biased toward engineering education, yet a few instructors from other areas (e.g., physics, math) also attend. The content for the NETI focuses around four core areas: understanding students (both their learning process and their hangups), course planning and assessment, developing teaching strategies, and other professional concerns. A recent paper by the workshop facilitators evaluates data received from past attendees on the success of the course.[8]

While the NETI has an engineering focus, the other teaching workshop that an author attended takes a multidisciplinary approach to the presentation of learning principles. The University of Prince Edward Island has hosted the Faculty Development Summer Institute (FDSI)[11] since 1984 and has both instructors and attendees from the humanities and the sciences. Over five days at the beginning of August, the content focuses on implementing techniques for active learning in the classroom. Specific areas of focus covered in the FDSI under the active learning umbrella include how to set the tone for an active learning class, how to motivate students, how to build active learning into the classroom, the interactive science classroom, group work and team learning, and assessment techniques for both student learning and teaching effectiveness.

Implementation

NETI

During the last day of the National Effective Teaching Institute, the presenters purposely encourage attendees to focus on an incremental approach to the implementation of workshop concepts and ideas. In addition to a section of the handbook[9] being devoted to this topic, a single page given the first day of the workshop helps attendees to focus on two or three ideas so that they are not overwhelmed by the content when they go to prepare their courses for the fall. Therefore, the author chose to focus on the addition of learning objectives, development of handouts with gaps, and implementation of an alternate grading scale.

The implementation of learning objectives affected not only the author's preparation for the course, but also how students could focus on the material. During the first semester of implementation, the author developed the learning objectives prior to reviewing past lecture notes. The objectives for a given lecture were then listed at the top of the lecture handout (which is provided for each class; discussed below) so that students could know what material to focus on during the class. Per the workshop's advice to be student-focused, each objective started with "Be able to...;" the verb that followed initiated a measurable and observable statement from which the instructor could assess student performance. Each objective derived from (the Revised) Bloom's Taxonomy of Educational Objectives.[3] Another key element when developing learning objectives includes dividing a task into its specific cognitive processes[2], so that students know how deeply to understand a concept. Before each exam, the author compiled all the learning objectives into a spreadsheet and made it available to the class as a study guide. Then, when creating exams, the study guide provided the focus for choosing/developing exam questions. Thus, the exam material would achieve the learning objectives at the same Bloom Level that had been taught.

In addition to the learning objectives, the development of handouts with gaps provided a means through which students could more easily enter the learning process at lower and higher levels of cognition (see example in Appendix A). Through their structure and appropriate coverage of the material, handouts with gaps enabled lower Bloom Taxonomy levels (Remembering, Understanding, Applying) to be covered and prevented that material from dominating the in-class time. The instructor could discuss this material briefly yet students still saw it highlighted by its presence on the handout. In addition, some partial and complete diagrams minimized pauses for

Table 1: Calculation of weighted course grade

Option 1		*Option 2*	
Homework	10%	Homework	10%
Laboratory	30%	Laboratory	30%
Exams (5)	60%	Exams (4)	30%
		Final Exam	30%

students to copy displayed figures or procedures. For difficult concepts or higher levels of cognition—analysis, evaluation, or design—gaps are left on the handout (hence the name) to allow open investigation rather than "spoon-feeding" of information.[9]

From the workshop's comparison of the diverse learning styles, the author implemented an additional assessment option for global learners. Understanding that "global" learners absorb information more randomly[7] and need the entire picture before they can put information together, assessment of these learners near the end of a course should more accurately reflect their mastery of the material. Therefore, the author developed two grading options for each course. In both options the only difference was the weighting given to exams. Table 1 shows an example.

Option 1 weighted each of the Exams in the course equally and dropped the (cumulative) Final Exam since a student would have shown sufficient mastery on the exams. This option would benefit the "sequential" learner who is able to put concepts and ideas together throughout the term. Option 2 dropped the lowest Exam, reduced the weight of the remaining Exams on the course grade, and included the Final Exam weighted with the percentage that was removed from the Exams. The second option enables the "global" learners who do not understand the material until later in the course to demonstrate that they obtained sufficient mastery of the material, while minimizing the penalty for the process to get there. It also allows "sequential" learners to recover from an Exam on a personal "bad day."

FDSI

The author attending the FDSI came to a greater appreciation of the effectiveness of implementing active learning techniques in the classroom in general. Because the FDSI was not a discipline or field specific workshop, considerable thought by the author was given to how to incorporate and adapt some of these general active techniques specifically to the engineering classroom. Examples of active techniques that were introduced at the workshop include quickwrites, fishbowl discussions, think-pair-share activities, debates, exit tickets, and in-class team learning. One of the largest hindrances to successful incorporation of such techniques in engineering courses is the amount of material that is routinely required to be covered in a typical engineering course. While many active techniques are very effective at introducing and ingraining new conceptual concepts to students, the reality is that almost all of them take more time in covering material than a traditional lecture. Thus, the author gave careful thought to how certain active techniques would improve learning without slowing course pace and eliminating necessary course content.

While the author has occasionally used variations of quickwrites and exit tickets (also called "muddy cards") with relative success, the active technique incorporated the most extensively to date is a variation of the in-class team-learning concept introduced at FDSI. The acronym the author has chosen for his particular approach to this team concept is TAAR, standing for "Team Analysis And Review." The TAAR is a team-learning tool that the author has found to work well for conceptually and analytically-intensive courses that are so prevalent in a typical engineering curriculum, and it will be described in the following paragraphs. While the particular form of team-learning employed in the TAARs has been developed by the author, it is based on a team-learning technique known as "CRIT" (Critical Reading and Issues Test). This group quiz technique was introduced at FDSI by its developer, Dr. Brent MacLaine, professor and chair of the Department of English at the University of Prince Edward Island.[11] Dr. MacLaine credits Dr. Larry Michaelsen, professor of management and business communication at the University of Central Missouri, as the primary source for team-based learning techniques.[10] Similar ideas for utilizing small-group strategies in large classes[5] and collaborative learning in study teams[6] have been used in various disciplines.

Briefly, a complete TAAR is accomplished in three stages. Stage 1 consists of students individually working through a short quiz that generally consists of multiple-choice or true/false questions. The individual quizzes are then turned in. In Stage 2, the students work through the same quiz in groups of four or five and then turn their completed group quizzes in. Finally, in Stage 3, the entire class is led by the instructor in a discussion of the same quiz.

The author's use of the TAARs over the past couple of years leads him to believe that there are several important aspects to consider to provide the best opportunity for successful implementation. First, it is important to provide enough time in the schedule for meaningful use. The author has found that a single three-stage TAAR exercise generally fits well into a full 50-minute class period. In addition, to develop successful team dynamics and make best use of the TAAR mechanism once it is established, six or seven TAAR exercises spaced throughout the semester of a typical three-credit class is probably a good minimum number to plan for. Thus, when considering that a typical three-credit semester-based class that meets for three 50-minute classes each week will meet approximately 42 times per semester, to implement the TAAR exercises effectively requires devoting approximately 17 percent (7 complete class periods) of the class time throughout the semester to them. This use of time might seem at first glance to be a direct contradiction to the point made earlier regarding the amount of material that needs to be covered in a typical engineering course. However, the author has found that the TAARs can become a very effective mechanism for self-instruction among the students if careful attention is paid to what material can likely be digested by the students in their own preparation outside of class time prior to a TAAR's class. Thus, the amount of class material that is covered in a more traditional lecture format can be reduced and certain well-suited material can be engaged in class only through the TAARs.

A second important point to consider with the TAARs is whether or not they should be graded exercises. The author believes that they serve primarily as a teaching tool, but in order for them to be the most effective, some students need to have some extrinsic motivation to participate actively and reap the greatest benefit. Thus far, where TAARs have been implemented, 10% of the final course grade has been based on the TAAR scores. The author has to this point settled on a breakout of basing 2.5% of the final grade on the individual TAARs and 7.5% of the final grade on the group TAARs. This scoring seems to provide enough incentive on the individual portion that students put forth good effort yet still puts a bit more emphasis on the group effort, where most of the learning and generally the better scoring occurs.

Another very important aspect of the TAAR groups is the formation of the groups themselves. The author's limited experience over the past couple of years seems to indicate that keeping the groups the same throughout the duration of the class forms the best comraderie among the team members and develops the best team dynamics and best learning environment. Of course, in order to use the same groups throughout the semester, the groups have to be initially established in a reasonably appropriate way. The method the author has used to establish the groups has been to have the students fill out a self-evaluated index sheet during the very first class of the semester. The indices are generally based on self-assessment of performance in related previous classes, understanding of certain basic concepts, and perception of leadership and groupwork skills. The idea with the indices is not to end up with a high score just based on academic intelligence, but to end up with a total high score only if a student assesses him or herself as strong in academics, comfortable with topics and skills that are foundational to the course at hand, and good at working with teams. (An example of a team index sheet is included in Appendix B.) When students complete and turn in the index sheets, the groups are generally established immediately during class by sorting the completed index scores from highest to lowest and then distributing the sheets, based on index only, to form groups with roughly the same total index scores. This distribution is accomplished by using the sorted stack of index sheets and distributing them into stacks (one stack per group) in an order similar to the order that is generally used for a sports fantasy draft (1, 2, 3, 4, 4, 3, 2, 1, 1, 2, 3, 4, etc.) until all the students are assigned to a group. The author's experience to date has shown that groups of four or five (preferably five) seem the best to facilitate good discussion and to generate active involvement among all participants. Additional research on ideal group size and formation of groups is available.[4]

As mentioned earlier, full implementation of periodic TAAR exercises likely requires reducing lecture time throughout the semester to free up room in the class schedule. Less lecture time likely results in more material that the students process on their own from the textbook or course material rather than having it distilled by the instructor during class time. Thus, a fourth helpful point regarding TAAR implementation is choosing a textbook that is accessible and understandable for students enabling greater opportunity to utilize TAARs effectively.

The type of course content that is covered on the TAAR exercises is another important aspect to consider. The format and time constraints on the TAARs during a normal class do not lend themselves well to lengthy analytical processes and calculations that are typical in engineering courses. Thus, a TAAR format is probably not wonderfully suited to an upper-level design course. However, TAARs do work very well for covering concepts and fundamentals. Appendix C provides an example of a typical TAAR exercise from Statics and Dynamics. The author's experience to date has shown that courses such as Statics or Dynamics, that are primarily based on introducing fundamental concepts and approaches, are prime candidates for using TAAR exercises as primary teaching tools. Creating an atmosphere for students to discuss, debate, and even argue about fundamental concepts and approaches seems to be an excellent way to cement the concepts for the students.

Finally, directly related to the type of content on the TAARs is how TAAR questions themselves are presented. The author has found that multiple-choice style questions are especially helpful when care is taken to develop wrong answers that match common misperceptions. Conceivable wrong answers simply add fuel to the fire of the students' discussions and also help to provide more interest, excitement, and active participation on the part of the students during the final discussion that is conducted by the instructor with the class as a whole.

A couple of active techniques other than TAARs that have been incorporated by the author as a result of discussion at FDSI include white board problems and and presentations. White board problems are problems that are perhaps a bit lengthier than typical TAAR problems and are used in a 10- or 15-minute time block to break up a traditional lecture. The class will be divided up into groups of 3–5 (in a class where TAARs are already being utilized, the TAAR groups work well for this exercise also) and presented the problem. They are then given a few minutes to work as groups, and then two or three groups are asked to come up to the white board at front and continue working as a group through the problem to completion. The work at the board might be a bit of a competition among two or three simultaneous groups, or it might just be one group working through the problem and explaining their approach to the class.

Student presentations of class topics have been utilized as a teaching tool by the author in one class that was well-suited to using them as such. While presentations as evaluation and interaction tools are quite common, the author believes that it is a bit rarer and more challenging to use them as a teaching tool for the rest of the class, but it can be a very effective technique in the right class if structured appropriately. In the author's implementation of this approach, the class was in a materials science course that contained students from broad engineering emphases including mechanical, civil, and electrical, all with their own unique interests in materials depending on their discipline. To employ presentations as a learning technique, the author stripped the primary material covered in the course down to a foundational core and used graded student presentations to present and teach other more discipline-specific material that was perhaps more well-suited to the presenters' interests. Non-presenting students were required to submit questions related to the presentations but also were aware that there would be homework and exam questions related to the presented material. Presentations were incorporated into the class schedule by using one full class period per week for presentations and using the other two class periods per week for a more traditional lecture format.

Evaluation

Though the knowledge and skills gained from the teaching workshops helped in key areas of developing quality learning environments, the authors also note that just having another year of experience provided tremendous value. One author recalls that throughout the workshop, he kept saying to himself, "Oh! That is why it did not work. And that is why this was unclear, etc." Yet, at the same time he could say, "This is how I can fix that! This will help that make more sense, etc."

Because the authors had at least a year of in-class experience, they could easily recall examples that workshop topics addressed for improvement. The authors also felt that they already recognized most of their areas of deficiency prior to the workshops, but they were not able to completely define the issues. Though they were making some changes to their instruction approaches, the workshops provided the insight to make the most effective changes immediately rather than working through a trial-and-error process for 10+ years!

NETI

The implementation of learning objectives were extremely helpful in enabling the author to clarify to what level a concept would be taught, while students had much more clarity on the expectations of mastery on assessment instruments (e.g., test/quiz, homework problems). From verbal feedback received during the course, the learning objectives provide on the in-class handouts were essentially ignored, but the separate compiled objectives were extremely valuable when studying for exams. The author's initial development of objectives left them generally worded (note the need to break down a task as mentioned above), so the refinement of the objectives is an ongoing process.

The handouts with gaps were a great start, but some had too much information for students to wade through. While still valuable, more gaps were necessary to allow room for student inquiry and investment in the learning process as well as providing structure for active learning activities. In some cases, students would note a point in the handout where they could fill-in material. Then, they would only listen for the keywords that indicated that the section was reached, thus missing some of the information discussed during the interim. The refinement process of the handouts with gaps showed the author that balancing the dissemination of information with opportunities for providing feedback/practice is difficult. Both are valuable and both take time. In addition, the author is slowly giving more responsibility to his students to gain lower cognitive-level understanding of the course material prior to a class where the corresponding higher cognitive-levels are practiced.

As for the grading scale options, while most students have not taken advantage of grading "Option 2," it has been valuable for the few that have. From the author's perspective, it seems that students will sacrifice a half-letter grade (take a B instead of a B+) if they can avoid taking another Final Exam. However, this past fall several students in one course took the Final and improved their course grade. An example of where this approach can benefit: one student had a (self-described) "brain fart" on one of the Exams and wanted to show that he really knew the material. His resulting course grade with Option 2 more accurately reflected his mastery of the material (in the author's view). In the end, the author believes that the combination of Options 1 and 2 (or similar approaches) more appropriately assesses student mastery of the material.

FDSI

Limited quantitative evaluation of class success in the sophomore-level Statics and Dynamics course where TAARs have been implemented the most extensively indicates that the TAARs have been helpful in improving student understanding of the class material. The class was taught for the past three years by the author: in 2008 without using the TAARs and then in 2009 and 2010 using the TAARs as a primary teaching tool. Each of the three classes culminated in a cumulative final exam that was not returned to the students. Although the exam was modified slightly from year to year, much of the exam content each of the three years was identical, and the general format of the exam remained the same with some FE-style multiple-choice questions and a few longer analytically-intense problems. In 2008, the raw exam mean for the class was 74.27. However, in 2009, which was the first class where the TAARs were used, the raw class mean on the final exam improved to 77.15, and in 2010, where TAARs were modified slightly and again used extensively, the raw class mean was even slightly higher at 77.85.

While the data provided in the above paragraph is definitely not statistically sufficient to prove that the TAARs have improved student learning, the author feels that the TAARs were influential in improving performance, and the numbers seem to support this feeling. While numbers alone are not sufficient to prove the value of the TAARs, additional anecdotal observations by the author and written and verbal evaluations from the students themselves also seem to support the TAARs' usefulness. The 2009 class was an interesting case study for the author, as this class was a "bubble" class in terms of size, as it was almost twice the size of the 2008 class. The author perceived some troubling class dynamics early in the 2009 class, including some "holier-than-thou" attitude difficulties, some clear stratifications within the class, and what seemed to be a prevalent attitude of lack of care regarding the course material at best, or distrust towards the instructor at worst. However, the author is happy to report that an exciting attitude shift seemed to occur throughout most of the group during that semester, and while this transformation cannot be entirely attributed to the TAARs, observation of the morphing student attitude and interaction throughout the semester seemed to indicate that the TAARs helped develop team and group dynamics within the class while at the same time helping the students learn the concepts and approaches being taught. Now almost two years later, with this group of students nearing the end of their third year of studies in the engineering program, it has been exciting to see these attitudes and group characteristics continue through the courses and activities in which they have been involved. Although the TAARs were certainly not the only factor in this development and progression, the author feels they certainly did play a small role in improving the teamwork and sense of community among this group of students.

It is interesting to note that, although students in both the 2009 and 2010 classes grumbled a little bit about the TAARs at mid-semester, both classes evaluated the TAARs very highly in end-of-the-semester student evaluations. A sampling of unsolicited comments from students on the written evaluations is provided here to give a bit of a picture of student attitudes towards them:

- "Continue lots of TAARs"
- "The TAARs were a good learning tool even though challenging at times"
- "The TAARs and group problems, no matter how frustrating they may be, were very helpful in understanding and creating a good situation for working groups"
- "The TAARs were helpful, even though they were painful"
- "The TAARs were good for thinking about the concepts behind what we learned but were also slightly stressful"

It is interesting and encouraging for the author that a repeating theme in the student evaluations was positive reception based on retrospective reflection. In addition, after a scouring of the student evaluations from the two classes where TAARs were employed heavily to highlight the negative comments toward TAARs, the author discovered that the only negative comments are those highlighted above. While they did not always enjoy the TAARs at the time they were doing them, when looking back at the end of the semester they recognized the value of the exercises. They observed and appreciated in hindsight that the TAARs had improved their understanding of the material and helped them learn.

One more anecdotal example may be helpful in building the evidence for usefulness and student appreciation of the TAAR exercises. The author received the following unsolicited comment on a student evaluation from an upperclassman in a higher level course where TAARs were not employed: “Even though I didn’t really ever like the TAARs, I feel that it wouldn’t hurt to do some in every class you teach. They always do a good job of engraving key concepts.” Though the class was one in which he was highly successful and one that he had thoroughly enjoyed, he thought back to the past year where TAARs had been employed in his Statics and Dynamics class. Clearly the learning he enjoyed from the TAARs left an impression in order for him to recall them on an evaluation of a course a year later. The author highlights this as a specific example but has received similar verbal affirmation on the TAARs from many students. The improved performance mentioned above and overwhelmingly positive feedback from the students has solidified the usefulness of the TAARs in the mind of the author (with potential extrapolation to active-learning techniques in general).

While it is difficult to quantitatively evaluate the effectiveness of white board problems, the author’s experience has shown that this technique can be very helpful and very well-received by certain groups of students but can perhaps be less embraced by other groups of students. Switching the format from a type of competition to more of a student-led discussion, or vice versa, can be helpful in making the technique more effective in classes with different group dynamics. A nice advantage of white board problems is that they are quite easy and low-risk to implement, do not take an entire class period, and are adaptable to a broad range of class concepts and analysis approaches.

The limited use of presentations by the author seems to be useful and engaging for the students. The format of interspersing the presentations throughout the second half of the semester adds variety in a fairly structured way by interspersing one student-led presentation class period among two more traditional lecture-format classes per week. The variation seems to keep the students engaged and interested. Also, reducing the traditional lecture time from three classes per week to two per week reduces the prep time for the instructor. However, this format may be challenging for typical engineering courses with information that continues to build and develop throughout the semester, because the class “leader” is in effect jumping between the instructor and the student presenters and does not provide the best continuity.

In closing, students have embraced the implementation of the TAARs over the past couple of years, and the author has seen good results, both quantitatively in exam scores and anecdotally in classroom dynamics, student interaction, and student evaluation. Other efforts to encourage active learning and participation in the classroom, including white board problems and presentations as teaching tools, have also been shown to be effective methods of improvement student engagement, participation, and learning.

Summary ("Tips-and-Tricks")

Learning Objectives

- Start each objective with "Be able to...."
- Add a verb from (the Revised) Bloom's Taxonomy of Educational Objectives.[3]
- Break down tasks into objectives that focus on specific cognitive processes, i.e., make sure they are not too general.
- Objectives should be measurable and observable.

Handout with Gaps

- Handouts with gaps provide structure for lectures (for both instructor and student).
- Care is needed to not overwhelm students with information; handouts should encourage students' investment in their learning.
- Handouts enable a structured environment for both dissemination of lower Bloom Taxonomy levels and investigation of the higher cognitive levels.

Learning Styles (Grading)

- A basic understanding of learning styles can help instructors recognize some of the learning struggles that students must overcome.
- Multiple grading scales provide course assessment possibilities that can accurately reflect student mastery of the covered material in spite of their learning style(s).

TAARs

- The process of working through quizzes individually first and then in carefully arranged teams seems to be a very good mechanism for facilitating active discussion and peer teaching among students.
- Embracing TAARs as a primary teaching tool does require the instructor to give up some lecture time, so courses need to be planned accordingly to fit nicely within the semester schedule; text and class material that are used should be accessible for students.
- Careful thought should be given to the content that is taught and reviewed in the TAARs so that it fits the format appropriately.

- Careful thought should be put into how the groups are formed so that student strengths and weaknesses relative to course material and teamwork can be spread uniformly among the groups.
- Careful thought should be given to the formation of the quiz questions themselves, including incorrect multiple-choice options, to facilitate the most productive discussion and participation from students.

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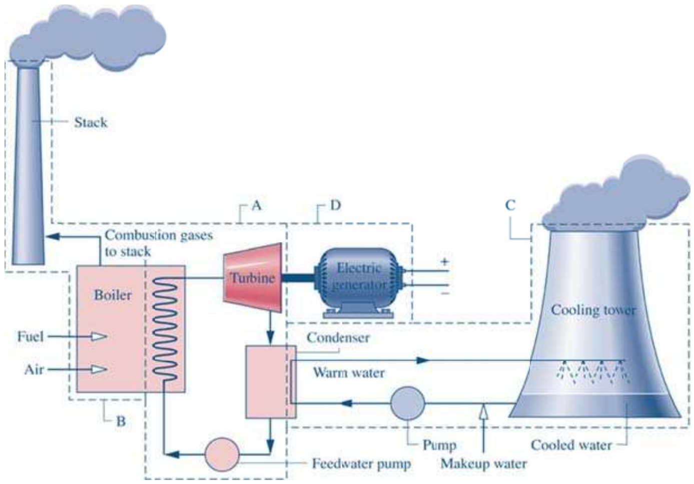
Appendix A

Example of Handout with Gaps

The gray area on the right side are comments (via the Review tab in Microsoft Word) for the instructor. They are hidden when student handouts are printed.

Vapor Power Systems

HW #5 (due 9/16): p.433, Exercise #7 (*NOT* 8.7)



Working fluid is alternately vaporized and condensed in the process to derive useful energy.

Process B: Heat is produced through combustion, nuclear, or solar process; waste products are removed

Process A: Heat produced in Process B vaporizes working fluid; expansion through the turbine generating work; working fluid condensed; pump increases fluid pressure

How the working fluid is vaporized:

- Fossil Fuels: combustion produces hot gases; heat transferred to working fluid through tubes and drums in boiler; product gases exhausted
- Nuclear: heat from reaction transferred to intermediate fluid, such as pressurized water, liquid metal, or gas (helium); intermediate fluid used in heat exchangers with working fluid; no immediate waste product, though radioactive material will need replacement
- Solar: solar radiation collected and concentrated to vaporize the working fluid; no waste product

Process D: From the work of the turbine, electrical energy is generated

Process C: Heat transferred from the working fluid to the cooling water in the condenser is rejected to the atmosphere in the cooling tower; makeup water is added to the cooling water and pumped back to the condenser

Examples via Google Earth…what do we see?:

Fossil Fuel Plants:

Comment [M1]:
- Water source nearby
- Source of fossil fuel?
- Cooling tower (for gas turbines?)
- Exhaust towers

Nuclear Plants:

Comment [M2]:
- Water source nearby
- Cooling tower

Principal Device Analysis

- Turbine:

Comment [M3]:
$$\dot{W}_t = \dot{m}(h_1 - h_2)$$
$$\eta_t = \frac{(\dot{W}_t/\dot{m})}{(\dot{W}_t/\dot{m})_s} = \frac{(h_1 - h_2)}{(h_1 - h_{2s})}$$

- Pump:

Comment [M4]:
$$\dot{W}_p = \dot{m}(h_4 - h_3)$$
$$\eta_p = \frac{(\dot{W}_p/\dot{m})_s}{(\dot{W}_p/\dot{m})} = \frac{(h_{4s} - h_3)}{(h_4 - h_3)}$$

- Boiler:
- Condenser:

Comment [M5]: $\dot{Q}_{in} = \dot{m}(h_1 - h_4)$

Comment [M6]: $\dot{Q}_{out} = \dot{m}(h_2 - h_3)$

Cycle Performance Parameters

- Thermal efficiency of power cycle:
  - $\eta = \dfrac{\dot{W}_{net}/\dot{m}}{\dot{Q}_{in}\ /\dot{m}} = \dfrac{\dot{W}_t/\dot{m} - \dot{W}_p/\dot{m}}{\dot{Q}_{in}/\dot{m}}$
  - Alternative form that ~~may~~ will be useful later: $\eta = \dfrac{\dot{Q}_{in}/\dot{m} - \dot{Q}_{out}/\dot{m}}{\dot{Q}_{in}/\dot{m}}$

Cycle Comparison (Cengel, 9-1,9-2)

- Carnot cycle (2 – adiabatic/isentropic, 2 – isothermal processes)
  - Most efficient
  - Impractical:

Comment [M7]:
- Limited maximum temperature (for process 4'-1 to stay in the vapor dome under the critical-point)
- Expansion (process 1-2) through turbine
  - Steam quality decreases
  - Liquid droplet impingement on turbine blades: erosion/wear
- Compression (process 3'-4') of a two-phase mixture
  - Difficult to control condensation process to end up at state 4
  - Not practical to design a compressor that handles two phases

- Ideal Rankine cycle (2 – isentropic, 2 – isobaric processes)

Comment [M8]: DRAW and discuss how it meets shortfalls of Carnot (slide figure does not show superheated vapor phase).

The ideal Rankine cycle includes superheating as a possibility.

Appendix B

Example of Team Index Sheet

DORDT COLLEGE
ENGINEERING DEPARTMENT

PAGE: 1 OF 1

COURSE: **EGR 210** SUBJECT: **TAAR Groups** DATE: 08/25/10

TAAR Groups – Indexing

Instructions: Choose the most appropriate point value from each index section (choose only ONE score from each category) and determine your total index score by summing the section scores. These index scores will be used to determine groups that will be used in TAAR and other group activities.

Name: ___________________________________

Discipline Index

1. You are a civil- or mechanical-emphasis engineering major 25
2. You are an engineering major still deciding on an emphasis. 20
3. You are an engineering science major 15
4. You are an engineering technology major 10
5. You are not involved with one of the programs listed above 5

Experience Index

1. You know immediately how many equations of equilibrium are applicable in a 2-dimensional (planar) situation 25
2. You know whether force is a vector or a scalar 15
3. You know whether the correct SI unit for force is kilogram or Newton 10
4. The only thing that comes to mind when thinking about force is Luke Skywalker 5

Leadership Index

1. I consider myself to be a natural leader who likes to help a group achieve its goals 25
2. I sometimes prefer to be a leader and sometimes prefer to be a follower 15
3. I prefer to help behind the scenes in quiet ways 10

Interest Index

1. I appreciated and thoroughly enjoyed learning about force, vectors, and other principles of basic engineering mechanics in my previous physics and engineering coursework 25
2. Vectors and related topics are interesting, and I am beginning to understand them 20
3. My physics and engineering courses have been pretty interesting for the most part, but I really haven't caught on to vectors 15
4. Physics at the college level really hasn't been my strong-suit 5

Overall Index Score

Sum up your scores from the above categories: __________

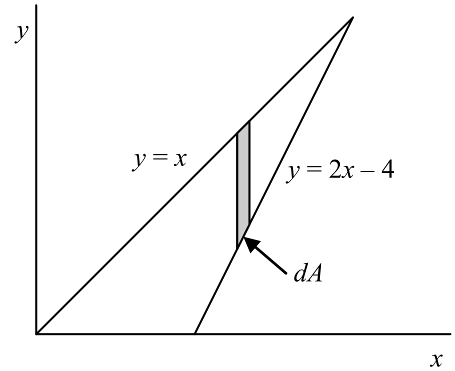
Appendix C

Example of TAAR Exercise

Engineering 210 — Statics and Dynamics **Name:**

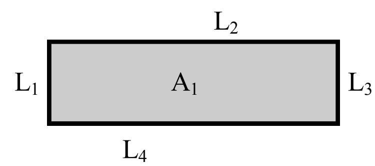
TAAR #3 — Chapters 5 and 9 Closed Book and Notes 09/28/10

1. If direct integration along the x-axis is to be used to determine the centroid of the area defined by the two linear functions shown at the right, the y-component of the centroid (y_{el}) of the differential element dA shown is:

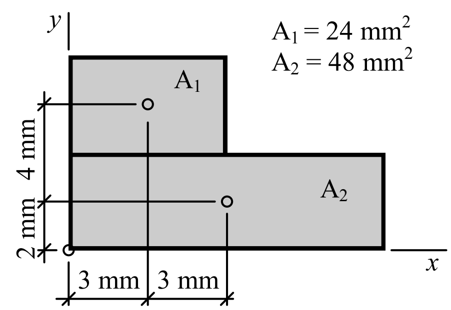


   a. $y_{el} = x$
   b. $y_{el} = -x/2 + 2$
   c. $y_{el} = (-x + 4)\ dx$
   d. $y_{el} = 3x/2 - 2$

2. True/False. For the shape shown at the right, the composite centroid of lines L_1, L_2, L_3, and L_4 is equal to the centroid of area A_1.



3. If the local centroids of A1 and A2 are located as shown, then the x-component of the centroid, defined from the origin, of the composite area shown at the right is:



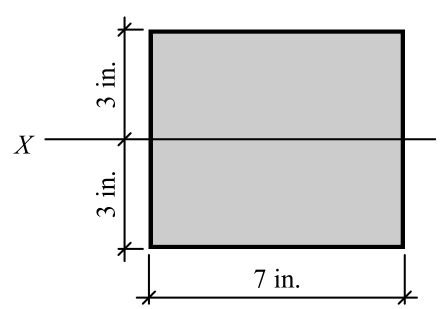
   a. 3.0 mm
   b. 3.3 mm
   c. 5.0 mm
   d. 6.0 mm

4. The first moment of area with respect to the X-X axis, Q_x, for the entire section shown at the right is:

   a. 0 in^3
   b. 31.5 in^3
   c. 126 in^3
   d. 504 in^3

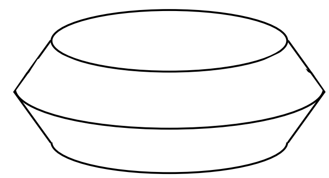
5. The moment of inertia with respect to the X-X axis, I_x, for the entire section shown at the right is:

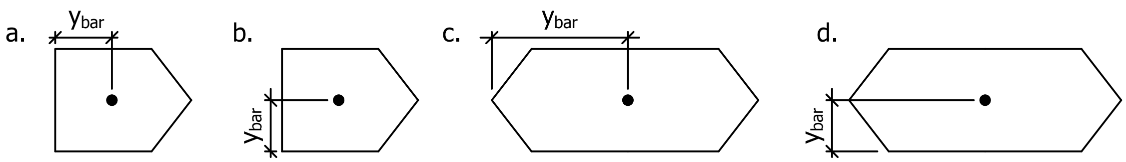
   a. 0 in^4
   b. 31.5 in^4
   c. 126 in^4
   d. 504 in^4



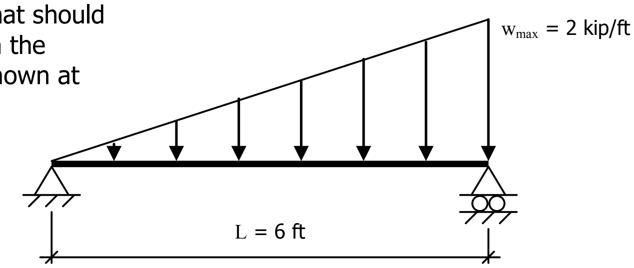
Section for 4 and 5

6. If the Pappus-Guldinus Theorem is used to determine the volume of the solid disk with angled edges shown at the right, which of the following choices correctly shows the area, A, and centroid distance, y_{bar}, that should be used in the equation $V = 2\pi\, y_{bar}\, A$?





7. The magnitude of the equivalent point load that should be applied when determining the reactions on the beam due to the triangular distributed load shown at the right is:



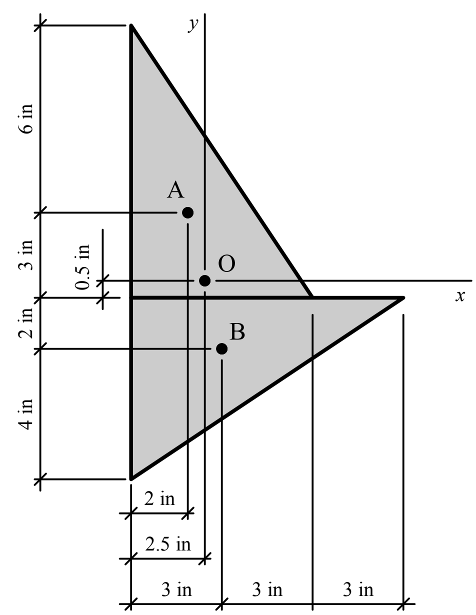
   a. 2 kips
   b. 6 kips
   c. 8 kips
   d. 12 kips

8. A section that has a moment of inertia about the x-axis of 500 in^4 and a moment of inertia about the y-axis that is double the moment of inertia about the x-axis has a polar moment of inertia of:

   a. 500 in^4
   b. 1000 in^4
   c. 1500 in^4
   d. 2000 in^4

9. If the section given in Number 8 above has an area of 100 in^2, the radius of gyration about the y-axis is:

   a. 2.24 in
   b. 3.16 in
   c. 5.00 in
   d. 10.00 in



10. For the composite section at the right, the moment of inertia of triangle A about a horizontal axis through point A (which is the centroid of triangle A) is I_{Ax}, and the moment of inertia of triangle B about a horizontal axis through point B (which is the centroid of triangle B) is I_{Bx}. Point O is the composite section centroid. Which of the following expressions is the composite moment of inertia about the x-axis through point O?

   a. $I_{Ax} + (27\ in^2)(2.5\ in)^2 + I_{Bx} + (27\ in^2)(2.5\ in)^2$
   b. $I_{Ax} + I_{Bx}$
   c. $I_{Ax} + I_{Bx} + (27\ in^2)(2.5\ in)^2$
   d. $I_{Ax} + (27\ in^2)(0.5\ in)^2 + I_{Bx} + (27\ in^2)(0.5\ in)^2$
   e. $I_{Ax} + I_{Bx} + (27\ in^2)(0.5\ in)^2$