AC 2011-646: USING A MOCK HEARING TO ENGAGE STUDENTS IN CRITICAL THINKING

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Abstract

Case studies are used in the *Introduction to Engineering* course as a method for incoming students to experience and evaluate examples of various engineering activities. A major objective of the case studies is to expose students to some aspects of the modern practice of engineering, namely: teamwork, problem and data analysis, design creation, presentation and defense of a designed solution, and professional ethics. The case study work is carefully structured to engage students in the engineering activities of critical thinking and analysis of a complex problem. Highly technical aspects of engineering requiring training not yet received by the students are avoided.

A common case study used in engineering training is the examination of the failure of the skywalk at the Hyatt Regency Hotel in Kansas City. This failure is beneficial for incoming students because the technical reason for the failure is straightforward and easily understood. However, understanding how the deficient walkway supports were allowed to be constructed and installed is challenging. Since most incoming students have little knowledge of the complex relationship of the design, fabrication, and construction steps in projects, some instruction in the roles and responsibilities of each entity is presented and discussed with the students at the beginning of this work.

In prior use of this case study in the *Introduction to Engineering* course, students were asked to read published papers reporting on this event, formulate an opinion on the party most responsible for the failure, and write a paper explaining and defending this opinion. These efforts were somewhat successful but seemed to fall short of truly engaging students in the difficult work of delving into the details, developing a full understanding of the problem, and logically reaching a defensible conclusion. In the fall semester of 2009, the approach was modified to include a mock hearing before the Professional Engineering Board of Licensure. The mock hearing allowed the students to assume the roles of the involved entities (owner, fabricator, project engineer, etc.) and represent each of these entities at the hearing. This paper presents a discussion of the modified approach used as well as the impact on class interest, enthusiasm, and student perceptions.

1. Introduction

All incoming students to the J.B. Speed School of Engineering are required to take the *Introduction to Engineering* course. The goals of the course are to introduce the new students to college campus life and resources, make the students aware of the different disciplines of engineering that might interest them, give them a feel for what engineers do, and introduce them to engineering software that they might use in school or profession to solve technical problems.

Case Studies are used in the *Introduction to Engineering* course as a way for the incoming students to experience and evaluate various aspects of the engineering profession. Many authors have pointed out the need for lessons learned from failure case studies in engineering education

[1,2,3,4,5]. A major objective of the use of case studies in *Introduction to Engineering* is to expose students to some aspects of the modern practice of engineering, namely: teamwork, problem and data analysis, design creation, presentation and defense of a designed solution, and professional ethics. Usually, two case studies are used each semester the course is taught. The case studies are carefully structured to engage students in the engineering activities of critical thinking and analysis of a complex problem. Highly technical aspects of engineering requiring training not yet received by the students are avoided.

One of the case studies used in 2010 involved researching and proposing a solution to a real world manufacturing plant's waste water problem. In this case study, the students are given a simple flow sheet, and process description of the manufacturing process. This information describes the sources of the waste water, sources of contaminant, and the level of contamination in each of the sources. The students are challenged to first understand the problem, and if needed, question their instructor for more information. After understanding the problem, students brainstorm for possible solutions and then perform individual research on potential approaches to treat, reduce, or eliminate the waste water. After each team member presents their individual research to their team, the team reaches an overall consensus on which approach to pursue.

The teams are given guidance on how to critically analyze each potential alternative using the Paul-Elder model for critical thinking [6]. Students are prompted to evaluate the potential of each approach to meet the plant's requirements of timing, safety, minimum cost of operation, minimum initial investment cost, and high probability of success. Since freshmen students don't have the skill set or time to rigorously calculate and estimate these items, they are given guidance about how to roughly judge each. For example, the students are to determine if their approach requires high temperature, high pressure, or toxic chemicals. If so, their approach would rate lower in safety versus an alternative approach that did not require the same operating conditions/parameters. Similar guidance is given to help in evaluating and supporting their conclusions on the proposal's ability to meet the other plant's requirements.

To culminate this case study, each team prepares a presentation for "plant management" proposing, explaining, and defending their recommendation for solution of the waste water problem. This presentation is given to their entire section of *Introduction to Engineering*, with the students in the audience playing the role of management. As such, they are asked to evaluate each team's presentation against the critical thinking rubric shown in Table 1.

Table 1: Critical Thinking Rubric

Consistently does all or most of the following:	
4	Clearly identifies the purpose including all complexities of relevant questions. Provides accurate, complete and relevant information and evidence. Complete, fair presentation of all relevant assumptions and points of view. Clearly articulates significant, logical implications and consequences based on relevant evidence.
3	Clearly identifies the purpose including some complexities of relevant questions. Provides accurate, mostly complete information and some relevant evidence. Complete, fair presentation of some relevant assumptions and points of view. Clearly articulates some implications and consequences based on evidence.
2	Identifies the purpose including irrelevant and/or insufficient questions. Accurate but incomplete information and irrelevant evidence. Simplistic presentation that ignores relevant assumptions and points of view. Articulates insignificant or illogical implications and consequences that are not supported by evidence.
1	Unclear purpose that does not includes questions. Inaccurate, incomplete information and irrelevant or no evidence. Incomplete presentation that ignores relevant assumptions and points of view. Fails to recognize or generates invalid implications and consequences based on irrelevant evidence.

The second case study used was the examination of the failure of the skywalk at the Hyatt Regency Hotel in Kansas City that killed 114 people and injured numerous others. This is a common case study used in engineering training, but it is usually used in higher level (particularly Civil Engineering) courses. This failure is beneficial for incoming students because the technical reason for the failure is straightforward and easily understood [7,8,9,10]. However, understanding how the deficient walkway supports were allowed to be constructed and installed is challenging, particularly for young students that have not experienced working in a large team on a complicated task. Since most incoming students have little knowledge of the complex relationship of design, fabrication, and construction steps in projects, this causes students issues in understanding and deep analysis of the problem. Therefore, it has been found that some instruction in the roles and responsibilities of each entity (owner, designer, architect, fabricator, general contractor, etc.) is necessary for the students to fully analyze the problem.

2. Details of the Hyatt Regency Case Study (2007, 2008)

The six main concepts about engineering that the students are exposed to as they perform activities in the Hyatt Regency case study are shown in Table 2.

Table 2: Overview of Hyatt Regency Skywalk Case Study – Engineering Profession Concepts

1	Engineering is often a team activity. This is particularly true in the Project, Design, Build and Operate aspects of engineering work.
2	Engineers conduct research, summarize data, reach conclusions from the data and determine logical inferences and recommendations for action.
3	Systems must be in place during all stages of engineering work to ensure quality and accuracy of the work.
4	Engineers formulate defensible and logical opinions based on data.
5	Engineers communicate findings and opinions (in written and oral formats) in a concise, complete, clear and accurate manner.
6	Engineers hold positions of responsibility. Engineers must hold paramount the safety, health and welfare of the public in all aspects of their work.

All in-class activities and homework assignments are linked to these six concepts. Prior to 2009, three two-hour class sessions were used for the activities and discussions of the Hyatt Regency Case Study. A fourth two-hour class session was added in 2009 for the mock hearing of the Professional Engineer Board of Licensure.

The Hyatt Case Study is introduced to the students by sharing historical information about the incident. During this initial session, each individual member of the team was assigned different material to read, and expected to bring pertinent information back to their team. In particular, each student was assigned individual questions that they were expected to have answered for their team. The readings are published papers reported in the literature covering this disaster [7,8,9,10].

In the second session, students were given a readiness test. This readiness test was designed to demonstrate that they were prepared to share their findings with their team. The technical reason for the failure of the skywalks was discussed during this class to help the students understand why the skywalks failed. The teams were then allowed time to discuss the "bigger" questions, such as: "How did this occur?", and "Who is most responsible?" Each individual student was then responsible for writing a one or two page paper expressing their opinion as to who was the most responsible and who shared some responsibility of the failure. The critical thinking rubric (Table 1) used to score their opinion paper was shared with the students beforehand.

In the third class session devoted to the Hyatt Regency collapse, a presentation was given to the class detailing all errors that were made by each of the entities involved in the disaster. The findings of the Kansas Professional Engineer review board were also shared with the students. Appendix A includes a summary of class activities per session for the four years that the Hyatt Regency case study has been used.

2.1 Addition of Mock Hearing to the Hyatt Case Study in 2009

The case study structure described in the first part of Section 2 was revised in 2009. This revision was an attempt to better engage the students in the difficult work of delving into the details, developing a full understanding of the problem, and logically reaching a defensible opinion. As mentioned, the case study had a fourth session added to allow the inclusion of a mock hearing before the Professional Engineering Board of Licensure. The belief was that the

addition of a mock hearing would offer multiple benefits to the students. The mock hearing would reinforce the concept that engineers hold positions of responsibility, and are expected to hold paramount the safety, health, and welfare of the public in all aspects of their work. Additionally, the mock trial would allow the students an opportunity to formulate a defensible, logical opinion based on the case data. The activity was designed to be engaging and fun for the freshmen students.

The addition of the mock trial was not the only revision to the case study. The second session was also changed to include a discussion and presentation of the roles and responsibilities of each entity (owner, designer, architect, fabricator, general contractor, etc.) involved in the design and construction process. This presentation was added based on the fact most incoming students had little knowledge of the complex relationship of design, fabrication, and construction steps involved in projects. Some of the terminology related to project work is unfamiliar to the incoming students. Most have not been involved in the design process, and are unfamiliar with the documentation, communication, and approval process involved. The process for change of design and the role each person plays in approval of design change is unknown by students, therefore covering this material at the start of the case study greatly aids in the development of their understanding and appreciation of the errors made in the design and construction of the Hyatt. Particularly, due to the reference articles assigned for reading were written for an audience expected to understand project engineering terms and responsibilities.

The third session was modified to prepare the students for the mock hearing. The mock hearing is designed such that teams of students represent the following entities: Engineer of Record, Project Engineer, Owner, General Contractor, Fabricator, Testing Agencies, and the Sub-Fabricator. The teams must develop a defense for who they represent. The team is expected to develop a defense document that has four main items:

1. Opening Statement: The defense strategy must be clearly stated, and the evidence that will be used to prove each entity's innocence must be reviewed.
2. Defense Witness List: The document must identify which other entities will be called in each defense. The questions to ask each witness, as well as their expected answers should be included.
3. Cross Examination Witness List: The next section of the defense document must identify which entities will be cross examined given the opportunity. The questions to ask each witness as well as their expected answers should be included.
4. Closing Summary Statement: The final portion of the document is a summary of how the testimony presented should show that the person represented is innocent or at most shares only partial responsibility for the disaster.

In the preparation of the defense, the students must use critical thinking skills. The first step is to understand the question or problem that is being addressed. The question itself is not difficult to understand, "Did entity X play a significant part in the failure?" Rather, the challenging part for new engineering students is that they first must develop an understanding of what the roles and responsibilities of the entities are. Since the incoming students do not know what these are, one of the important steps for them to accomplish is to recognize that they do not have all the information and understanding to begin to answer the question. This understanding can be gained from lecture material as well as from assigned readings for the team. After understanding

the roles, they must now be able to separate pertinent information regarding their entity's actions at meeting the responsibilities, and to locate unfulfilled obligations by other entities involved. This research activity, compilation, and prioritization of pertinent, accurate facts are key steps in critical thinking. A critical thinker would next proceed, using all the data in a logical, analytical approach to reach a conclusion and eventually assign a degree of responsibility to each of the entities involved.

However, in the mock hearing defense preparation the students are asked to do something else besides just apply critical thought. The students are told to ignore or minimize data that might indicate their client is responsible, and if possible, undermine the motives and reliability of anyone that tries to implicate their client through cross-examination. This portion of the assignment is designed to highlight that if data are ignored or dismissed how an incomplete or incorrect conclusion may be reached. In this particular case, most students readily recognize the fallacy of such an approach. By seeing this clearly demonstrated, the expectation is that in the future as they approach new problems and new sets of data, they are careful to include all data in their thinking about the problem and certainly to question whether or not they have all pertinent data.

In the fourth session, the actual mock hearing is held. A mock Professional Engineer Licensure Board (3 member panel made up of J.B. Speed School of Engineering professors) conducts the hearing and controls the proceedings. This hearing begins with a reading of the purpose of the hearing by the board. All students are expected to be prepared to represent their assigned entity. Before the hearing starts, teams are selected and then informed of their selection for active participation in the hearing. The students not identified for an active role in the hearing serve as expert witnesses and as the jury pool. At the conclusion of the hearing, students' opinions as to the degree of responsibility of each of the parties are polled. The case study concludes with general discussion between the students and professors regarding engineer's roles and responsibilities.

2.1.1 2009 Observations

The introduction of the mock trial injected a feel of energy into this case study. Students' discussions during preparation of their defenses and their energy level the day of the trial was very high. The general attitude from the students was that this was not just another assignment. This assignment posed something a little different from their normal homework assignments, which generally involve a writing assignment and submitting it for grading. This activity was different, because it contains an oral discussion in front of a large group. The fact that peers could evaluate their preparation and performance likely contributed to some of the energy and anxiety. Most of the students seemed comfortable playing the defendant roles. However, a few students did not seem comfortable with their role. This was probably due to being nervous speaking in front of a group or lack of preparedness on their part. The atmosphere in the class was very supportive for those students that:

a) Clearly had an argument strategy;
b) Had a logical list of defense questions;
c) Were prepared and organized in their delivery which allowed the arguments to be clear, concise, and complete.

Overall the mock trial appeared to be an effective way to reinforce key concepts about the engineering profession. Particularly in this case study, the high level of responsibility that all engineers have working together on a project is demonstrated. The students are also challenged to understand the engineering profession. In addition to this challenge, they must critically think about how the failure occurred and what could and/or should have happened to prevent the disaster. The trial gives students a chance to demonstrate their understanding in a different way than typical written communication. This different format seems to be engaging for most students.

3.1 2010 Revisions to the Hyatt Regency Case Study

Following the 2009 *Introduction to Engineering* course, there were some items that could be improved. Students' papers showed some confusion based on project roles and responsibilities still existed. The project role discussion was made more explicit in how each role connected to the Hyatt Regency case study. A discussion of how "change of designs" (CODs) should occur and the proper documentation process for COD execution were added to the discussions.

Another area for improvement was aimed at assisting the students' development of a better defense argument/document. An extra review time was added to allow the instructors dedicated in class time to review the defense strategies and witness questions with the students. In turn, this allowed the students extra time for defense development and refinement.

3.1.1 2010 Observations

Based on the quality of the defense papers, the students understood the terminology related to project design and the role of each entity in the project better than the previous year. However, it is obvious to the course designers that the defense draft review process still needs additional improvement to assist the students with their defense strategy and witness questions. This could be facilitated by further training the graduate teaching assistants to help provide more useful feedback to the teams.

4. Survey Results

The *Introduction to Engineering* course has had multiple surveys administered regarding case studies. In this section, the results of two of the surveys will be presented.

The twelve questions are broken into two different types of questions. The first eight questions are Likert scale questions with responses (Strongly Agree, Agree, Neither Agree or Disagree, Disagree, Strongly Disagree) and the last four questions are 1-10 scale questions (with 1 being the lowest and 10 being the highest). The students are asked these questions after the Hyatt Regency case study has been completed. The prompt the students receive before the questions informs them to answer based on the Hyatt Regency case study only. The questions follow (and the 2008, 2009, and 2010 responses are summarized in Table 3):

1. Develop in students the ability to apply knowledge from math, science and engineering?
2. Develop an ability to analyze and interpret data?

3. Develop student competence in the design of systems, components, and processes to meet specific needs?
4. Train students to identify, formulate and solve engineering problems?
5. Instill in students an understanding of professional and ethical responsibilities, both in education and in practice?
6. Develop and practice effective written and graphic communication?
7. Create awareness in students of the need for life-long learning, whether through formal education or via many other means?
8. Expose students to contemporary issues pertinent to the practice of engineering?
9. What was your level of interest in the case? Did you find it interesting?
10. What was the educational quality of the case? Did you learn anything?
11. What was the quality of the presentation? Organized? Good visuals?
12. What is your overall rating of the case, combining the previous factors?

Table 3: Student Feedback on the Hyatt Regency Case Study (Percent of Student Responses) (Questions 1-8: Likert Scale) (Question 9-12: Are Rating Questions with 1 being the lowest and 10 being the highest)

	2008 (340 students surveyed)			2009 (317 students surveyed)			2010 (364 students surveyed)		
	Agree or Strongly Agree	Neither Agree nor Disagree	Disagree or Strongly Disagree	Agree or Strongly Agree	Neither Agree nor Disagree	Disagree or Strongly Disagree	Agree or Strongly Agree	Neither Agree nor Disagree	Disagree or Strongly Disagree
1	74	16	10	67	22	11	62	21	17
2	86	8	6	82	11	7	83	11	6
3	80	13	7	71	20	9	65	22	13
4	80	13	7	76	15	9	72	18	10
5	89	8	3	85	11	4	91	6	3
6	68	22	10	65	28	7	70	20	10
7	73	17	10	67	25	8	62	28	10
8	84	11	5	80	16	4	85	9	6
	Avg Score (scale of 1 to 10)	**Sum of % students responding >=7**		**Avg Score (scale of 1 to 10)**	**Sum of % students responding >=7**		**Avg Score (scale of 1 to 10)**	**Sum of % students responding >=7**	
9	6.4	57		6.2	53		6.3	57	
10	7.3	77		6.8	67		6.7	60	
11	7.7	80		7.1	69		6.9	65	
12	7.2	74		6.9	69		7.0	67	

Starting in the fall of 2009, a second survey was added to the *Introduction to Engineering* course at the University of Louisville. This survey is currently scheduled for four more years. At the end of the five years, the usefulness of this survey will be evaluated. The following ten-question survey and was completed by the students after the completion of two case studies (Wastewater Treatment, and Hyatt Regency Collapse):

1. How well did the case study Classroom Lectures contribute to your interest in the engineering profession?
2. How well did the case study Group Activities contribute to your interest in the engineering profession?
3. How well did the case study Independent Research contribute to your interest in the engineering profession?
4. How well did the case study Projects contribute to your interest in the engineering profession?
5. How well did the case study Readings and Supplements to the Lectures contribute to your interest in the engineering profession?
6. How well did the case study Classroom Lectures contribute to your understanding in the engineering profession?
7. How well did the case study Group Activities contribute to your understanding in the engineering profession?
8. How well did the case study Independent Research contribute to your understanding in the engineering profession?
9. How well did the case study Projects contribute to your understanding in the engineering profession?
10. How well did the case study Readings and Supplements to the Lectures contribute to your understanding in the engineering profession?

The survey administered was a self-reported Likert scale survey with valid input from the students being: 5-Very High, 4-High, 3-Moderate, 2-Low, 1-Very Low. The ten questions are broken into two categories: Questions regarding change in interest (the first five); and Questions regarding change in understanding (the last five).

The average responses for the 2009 freshmen who consented to their survey usage are shown in Figure 1 and Figure 2.

Figure 1: 2009 Average Response of Self-Reported Interest (353 students surveyed) (Likert Scale: 5-Very High, 4-High, 3-Moderate, 2-Low, 1-Very Low)

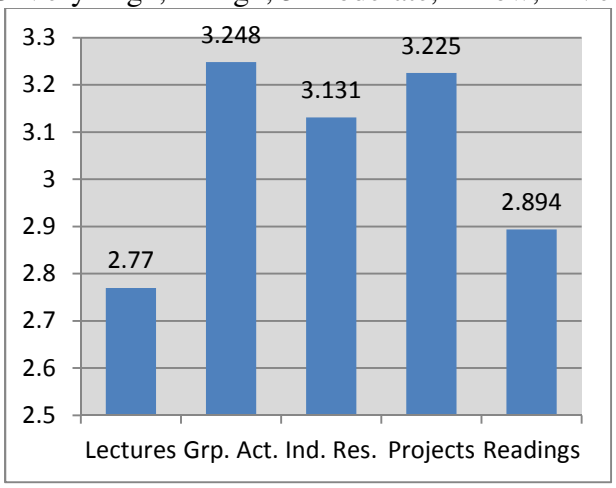
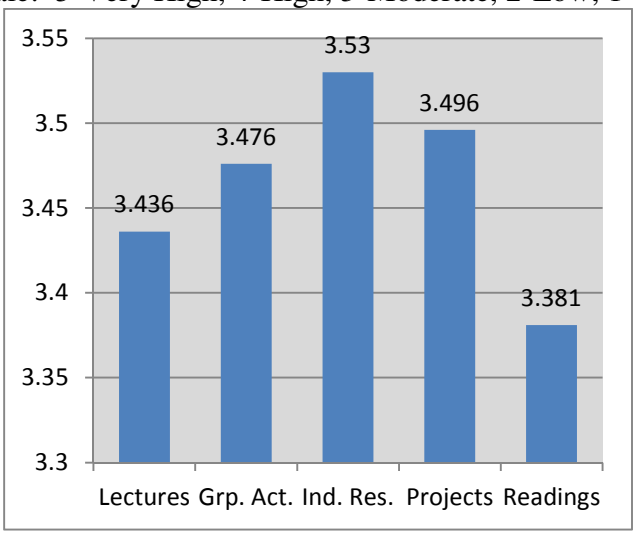


Figure 2: 2009 Average Response of Self-Reported Understanding (353 Students Surveyed)
(Likert Scale: 5-Very High, 4-High, 3-Moderate, 2-Low, 1-Very Low)



5. Conclusions

The data presented in Table 3 shows the students responses to the Hyatt Regency case study survey for the past three years. Comparing the pre mock trial (2008) to the mock trial years (2009, 2010), the questions that relate to developing abilities have decreased in the percentage that Strongly Agree or Agree, though this is not statistically significant. This could be due to the focus on the public presentation that is the mock trial. The public presentation of their arguments is important for the future work in companies that will expect them to communicate their thoughts and ideas. The question dealing with understanding professional and ethical responsibilities increased. This is likely due to the increased time spent discussing the responsibilities (professional and ethical) of each of the entities in the Hyatt Regency case study. The four class meetings devoted to each case study are an efficient way to introduce the students to this wide variety of engineering practices and professional ethics.

The summary statistics (averages>3) in Figure 1and Figure 2 indicate that students benefitted from the case study activities by increasing the students' interest and understanding of the engineering profession compared to their interest and understanding when entering the J.B. Speed School of Engineering. By increasing the interest and understanding of the engineering profession, this should:

1. Broaden student understanding of the impact of engineering solutions in global and social contexts; and
2. Increase students' ability to apply knowledge of engineering to real life situations.

These are two benefits to the case studies that are positive to freshmen engineering students and help foster interest and understanding for engineering challenges earlier in their college career. The surveys conducted, while not statistically significant, support the decision to continue spending the valuable course time on the case studies.

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Appendix A: Summary of Hyatt Regency Case Study Class Activities

	2007, 2008	2009	2010
Session 1	1. Introduce Case Study Learning Objectives, Assignments and Historical Information on the disaster. 2. Students (as part of a team) are assigned article on the disaster and individual questions to answer.	Same as 2007, 2008.	Same as 2007, 2008.
Session 2	1. Students are tested on their specific questions to make sure they are ready to participate. 2. Lecture on the Technical cause of the failure of the skywalk. 3. Students work in teams, discussing who should be held most responsible for the disaster. Assignment is to create a 1 page opinion paper on who is most responsible.	Same as 2007, 2008 except that after the team discussion, a lecture on design and construction roles and responsibilities is held. The intent is to clarify what the owner, engineer, fabricator, general contractor, architect roles contribute and what their responsibilities are for the project.	Same as 2007, 2008, 2009 except that: 1. A simplified and direct discussion of project roles and responsibilities is conducted. How design information is documented and communicated is detailed. In particular, discussion of the responsibilities around change of design communication is included. 2. Students are introduced to the Mock Trial that will be held to determine which person or company had the most responsibility in causing the Hyatt disaster. 3. Students (as a team) must prepare a Defense document that contains strategy, opening and closing statements and lists of questions to ask defense witnesses. Cross-examination question are also to be listed.
Session 3	1. Students turn in report that details the technical reason for the failure, the answers to their individual questions they were to answer and their opinion paper on who was most responsible for this disaster. 2. Lecture/Discussion on errors made by each person/entity involved in the disaster. PE Board findings and penalties discussed.	1. Students are introduced to the Mock Trial that will be held to determine which person or company had the most responsibility in causing the Hyatt disaster. 2. Students (as a team) must prepare a Defense document that contains strategy, opening and closing statements and lists of questions to ask defense witnesses. Cross-examination question are also to be listed.	1. Students review their defense drafts with instructors. 2. Students work on the improvement and clarification of strategies and witness questioning.
Session 4	No session 4	1. Mock trial is held. 2. Persons not actively participating in trial are in the jury. 3. At end of trial, jury polled and asked to assign level of responsibility of each person/entity.	1. Mock trial is held. 2. Persons not actively participating in trial are in the jury. 3. At end of trial, jury polled and asked to assign level of responsibility of each person/entity.