Developing Engineering Ethics through Expert Witness Role Plays

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This paper describes the development and formative assessment of an expert witness role play based on traffic crash reconstruction designed to develop engineering ethics. The paper begins with a short overview of ethics education pedagogies. Then, it describes expert witness role play as an approach for teaching engineering ethics and provides the specific example of a developed role play. Next, results from formative evaluation using participant self-reports of the role play experience are provided. The paper concludes with a description of important considerations for developing an expert witness role plays in other areas of engineering expertise and future steps for developing the expert witness role play approach to engineering ethics.

Engineering Ethics Education Pedagogies

Although ethics education is a vital component to science and engineering degrees, it is often difficult to develop effective and engaging ethics learning experiences within the degree programs. The goal of these programs is to produce not only technically competent, but also ethical professionals. Standard pedagogies expose students to broad ethical dilemmas that provide valuable practice in ethical reasoning related to these problems. However, for ethics education to resonate with the students, the education should be practical, personal, and involving. Students can participate in lectures and case studies on professional ethics as scientists without realizing the nature of the challenges that they may face in their chosen area of science or engineering. One solution to the limitations of some of the more traditional approaches to ethics education has been to use the role play pedagogy. This approach has shown promise in multiple fields such as engineering, medicine, and business for other learning outcomes. It has also been used in science and engineering to teach responsible conduct of research with some success.[1,2]

The most common form of ethics training is classroom-based, instructor-led training.[3,4] Typically, the instructor provides information to the trainees regarding the profession's ethics policies, rules, and regulations. Instructor-led training programs mostly rely on lecture-based presentations and individual reading and writing assignments[5] whereby trainees assume a passive role in learning. Traditional classroom training has advantages and disadvantages. It is the most common, expected, and accepted approach for training across a variety of learning goals. Additionally, this training has been shown to have the desirable effect of overall improvement in ethical outcomes.[6] Through passive engagement in the training content, students may learn the rules, regulations, and policies of a profession, but it may be that students do not learn the best strategies for enacting these principles. Traditional classroom training programs do not include the real-life pressures that are present in many actual ethical dilemmas. For example, in traditional classroom training, learners are informed what the ethical decision may be in an example situation. However, when the real-life situation is ethically ambiguous, the decision is much less clear. Little attention is given to discussing the difficulty associated with making an ethical decision and enacting the decision. By focusing on informing students about policies and rules, the training ignores the recognition, judgment and intention aspects of the ethical decision making process.

To overcome some of the limitations inherent in traditional classroom training, case studies have been incorporated into ethics training and education. Case studies present real ethical dilemmas that are relevant to an organization.[4] The educator presents the students with a vignette describing an ethical dilemma. Students are then invited to suggest courses of action that should be taken. The educator would then discuss potential consequences of the suggested actions and provide alternative solutions if necessary. Thus, case studies provide an avenue to think about, decipher, and discuss the available choices and potential consequences in an ethical dilemma.[5] By incorporating case studies into an ethics education program, the student transforms from a passive learner to an active participant in the learning process. Training programs that incorporate case studies tend to have a medium effect on increasing overall ethical behaviors. [6] Despite changing the trainee into an active learner and better overall ethical outcomes, case studies impose limits and boundaries in a controlled setting that prevents trainees from experiencing the psychological pressures inherent in ethical dilemmas. Although case studies allow trainees to think about specific ethical dilemmas and decisions, they do not allow trainees to practice enacting decisions.

Simulation exercises are activities that resemble an organizational situation in which employees are expected to display overt behaviors in response to complex stimuli.[7] Simulation exercises are most commonly researched as essential components in assessment centers.[8] However, organizations also use a specific type of simulation, role-plays, as a method of training employees on some competencies. Role-plays are simulations in which one or more participants take on the role of an organizational actor with a specific task and back-story. The back-story creates expectations and issues that need to be resolved. The participant(s) then attempt to resolve the issue during an interaction with another participant. The use of role-plays in training is not as prevalent as other ethics training methods. Despite their limited use, role-plays have the potential to improve ethics training.

Because role-plays require individuals to take on an identity and interact with another individual as if the situation were real, role-play simulations tend to have higher psychological fidelity.[9] Thus, they are thought to be effective at forcing participants to feel the emotions of a situation and to display skills needed in an actual situation. Further, they are intended to develop awareness of the difficulty of enacting the decisions that a person makes in a realistic situation. A single role-play can open students to the realistic difficulties involved with following through on decisions.[1] Thus, role-plays have the potential to show different perspectives on a problem, improve the depth of understanding, and capture participants' attention because of the experiential nature and realism of the training design. However, there are some concerns about role-plays that may limit their usefulness. For example, role-plays can also lead to resistance and awkwardness in the trainees.[1]

Expert Witness Role Play Design

Based on previous results on professional ethics training and education,[6,9] investigating the potential of the role-play in training engineering ethics shows promise. Expert witness role plays expand on this base of knowledge to help students develop practical skills to deal with the ethical challenges of maintaining scientific objectivity as an expert witness in their specific area of

study. The realism and specificity of these role plays has the potential to make ethics education more personal, skill-based, and memorable.

The expert witness role play is based on the author's expertise in traffic crash reconstruction. The materials and evidence were adapted from a real traffic crash test where no one was actually in the cars. These materials included images from the scene, a forensic map, a summary of the accident, and a summary of the current law suit. The engineering students were asked to act as expert crash reconstructionists. The students analyzed the case and submitted a written expert report regarding the case based on Rule 26 of the Federal Rules of Civil Procedure. Then engineering students were deposed by law students on one side of the case based on the contents of their report. Over three years of teaching using this approach, the effects of having engineering students act alone or in teams and the influence of submitting a complete Rule 26 report prior to the deposition were explored.

The students analyzing this scenario employed traditional dynamics concepts like impulse and momentum, work and energy, and kinematic relationships to determine vehicle speeds, times, and distances as explained in text books regarding traffic crash reconstruction[10] and dynamics. The evidence provided should lead the engineering students to conclude that one of the drivers was speeding and the other did not come to a stop at the stop sign. The role play scenario had the law students try to influence the results of the engineering analysis to help and advocate for their side, thus exposing the engineering student to an ethical decision on whether or not to withhold or falsify findings.

Crash Analysis and Deposition Role Play

The objective of this exercise is to evaluate information and determine expert opinions based on dynamics concepts to determine who was at fault in a traffic crash. The opinions will be used to provide testimony in the form of an expert witness report following the Federal Rules of Civil Procedure Section 26 (i.e. a Rule 26 report) and a verbal record by providing a deposition. The purpose of a deposition is for attorneys to obtain sworn testimony from witnesses in an attempt to understand the opinions that will be rendered in court. For this particular case engineering students will be required to present an enumerated list of opinions and be able to justify them in a legal proceeding. While the format of a deposition may vary, the following questions and themes are generally followed:

1. When did you become involved with the case?
2. What were you asked to do?
3. What did you actually do?
4. What are your opinions?
5. What is the factual basis for your opinions?
6. Is there any room or basis to challenge your opinions (i.e. do you make too many assumptions in your analysis)?
7. Are there any other thoughts or opinions that you would present in court?

The Crash Scenario

The following scenario is given to mechanical engineering students in a senior level class called Machine Dynamics.

On the morning of Tuesday, October 26, 2010 Julie Smith was driving her Buick Century north on Merrily Way while taking her three-year old daughter, Kate, to day care. At the same time, Joseph Olson was driving westbound on Elm Street in his Hyundai Accent to his first class at the local community college. The morning was crisp and the leaves were starting to turn. It was about 9:00 am and the sun was warming the day in a cloudless sky. It was just like any other normal day.

However, both vehicles tried to occupy the same section of pavement at the same time. The collision was severe enough to put all occupants in the hospital. Ms. Smith suffered a broken arm and concussion. Little Kate had a piece of glass or debris cut her ear. They were both wearing their seat belts. Mr. Olson did not fare as well. His injuries were severe with a compound femur fracture, broken wrist and severe lacerations on the head and neck. Evidence at the scene showed he was not wearing his seat belt. After 1 week in the hospital, Mr. Olson passed away. The police obtained a warrant for cell phone records and discovered that Mrs. Smith has sent 5 text messages and placed 1 phone call during the morning of the incident. The last text message was placed at 8:57:34 AM and the first 911 call for the crash was at 8:58:45 AM.

An official police report was prepared from the incident that contained information with drawings, dimensions, and weights. The intersection was controlled with a two-way stop sign. The speed limit northbound on Merrily Way was 25 mph and the speed limit on Elm Street was 35 mph. Merrily Way had the stop sign. The stop sign was 25 feet behind the front axle of the Buick when the collision occurred. The conclusion of the police report is to charge Ms. Smith for Vehicular Manslaughter as they claimed she did not stop at the stop sign and her gross negligence lead to the death of Mr. Olson.

The law in Oklahoma (Title 47, Chapter 11, Article 9 [§ 11-903]) for Negligent Homicide states:

> When the death of any person ensues within one (1) year as a proximate result of injury received by the driving of any vehicle by any person in reckless disregard of the safety of others, the person so operating such vehicle shall be guilty of negligent homicide.

Ms. Smith gave a statement to the police that she looked both ways and didn't see anyone. She drives this route frequently and did not remember if she came to a complete stop. She remembered running late that morning and was fearful of losing her job because she was a single mother.

The Student Assignment

Break into 2 teams comprising at least 1 engineering student and 1 law student each (4-6 people total). By mutual agreement or a flip of a coin, decide which team will represent the State and prosecute Ms. Smith for the manslaughter charge and which team will defend her. Each engineering student is to determine both vehicle speeds and determine if it was possible for Ms.

Smith to have come to a complete stop at the intersection. Engineering students must work with the law students to prepare a written report summarizing their findings. After at least 2 weeks, the group will meet to exchange depositions. The prosecuting law student will depose the engineering student working for the defense for 30 min. Then, the law student working on the defense will depose the engineering student working for the prosecutor. The depositions will be video recorded and evaluated by faculty and researchers for consistency and accuracy. A summary of the opinions regarding this case must be turned in. The following opinions should be given:

1. How did the vehicles come together? What were there orientations?
2. The speed of the Hyundai at impact.
3. The speed of the Buick at impact.
4. The speed of the Hyundai at the beginning of its skid.
5. The speed of the Buick at the beginning of its skid.
6. The change in velocity of the Buick.
7. The change in velocity of the Hyundai.
8. The Principal Direction of Force (PDOF) of the collision on the Hyundai (i.e. the direction of the impulse vector).
9. The Principal Direction of Force (PDOF) of the collision on the Buick (i.e. the direction of the impulse vector).
10. Why did the crash occur?
11. What could have been done to avoid this crash?

Supporting Documentation

The documents and photographs provided and referenced in this section were also provided to the participants to allow them to develop their opinions on the crash.

Since this is an ethics exercise, guiding documentation regarding the ethics related to crash reconstruction are published by the Society of Automotive Engineers (SAE) as shown by an image of the title block of J2314 in Figure 1. The standard includes general engineering ethics by reference and enumerates the following ethical concepts specific to reconstruction:

1. Competence
2. Truthfulness/Openness
3. Conflict of Interest/Privileged Information

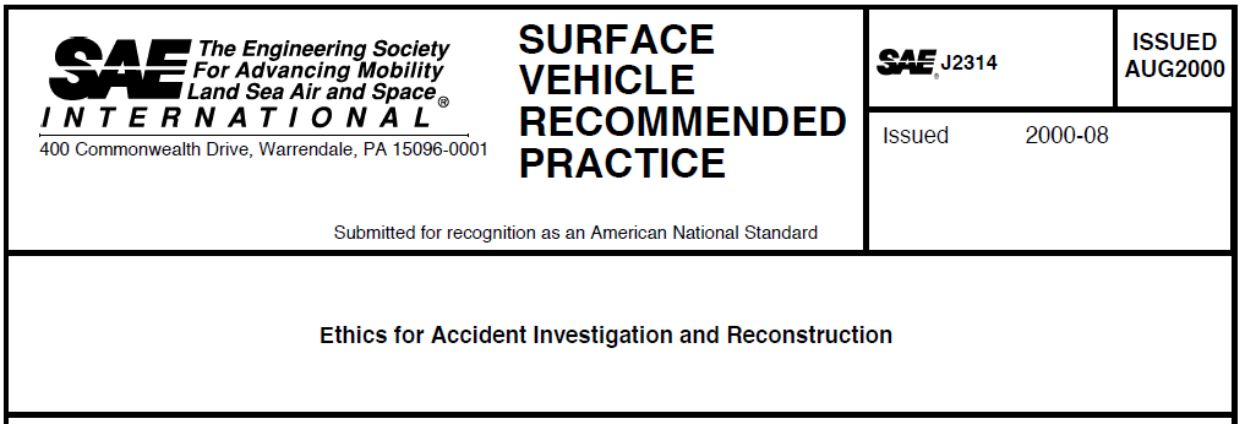

Figure 1: Title Block for the SAE Standard on Ethics for Accident Investigation and Reconstruction.

An aerial view of the crash scene is show in Figure 2. The Buick is pictured at the top of the photograph and came into the crash from the bottom left. It was impacted in the front right, which disabled the right front wheel and kept it from rolling. A curving scuff mark can be seen trailing the Buick. The Hyundai (labeled as 2), is the vehicle in the forefront of Figure 2. It sustained front impact damage after coming into the Buick from the bottom right of the photograph. It was a 90 degree impact. The Hyundai rotated about 180 degrees and rolled backwards. The discolored pavement in front of the Hyundai is from coolant and other engine fluids that were deposited on the ground after the crash. The tire scuffs and fluid deposits help identify the point of impact.

Figure 2: Overhead view of the crashed vehicles at their final rest position.

Close up photographs of the vehicles are shown in Figure 3 and Figure 4. The red and white rope showed attached to the Hyundai are remnants of the cable tow system used for this staged crash.

The scenario described earlier is an embellishment to provide some back story. In reality, this crash was part of a training conference put on by the Pennsylvania State Police in 2010.

Figure 3: Side damage to the Buick showing the disabled front right wheel.

Figure 4: Frontal damage to the Hyundai.

The Buick and the Hyundai have tires with similar composition.. An exemplar vehicle with similar tire compounds was obtained and 5 braking tests were performed. A representative graph of the accelerometer trace is shown in Figure 5 and summarized in Table 1. The road was level in both directions. Based on the 5 tests, the students should determine a statistical range of the likely friction value during the time of the crash. Keep in mind, the post impact path of the Buick showed only the right front wheel was braking. Therefore, the total friction force is reduced from a full locked wheel skid based on the percentage of load carried by the disabled wheel.

The scene data was gathered using forensic mapping techniques and presented in a CAD map shown in Figure 6. The forensic map provides engineering measurements to the scene evidence shown in the photos.

The Buick weighed 3540 lbs. and the Hyundai weighed 2150 lbs. Using these weights, the evidence from the scene diagram and a friction value based on the testing data, the students should get impact speeds around 25 mph for the Buick and 50 mph for the Hyundai. These calculations are based on conservation of linear momentum in a plane.

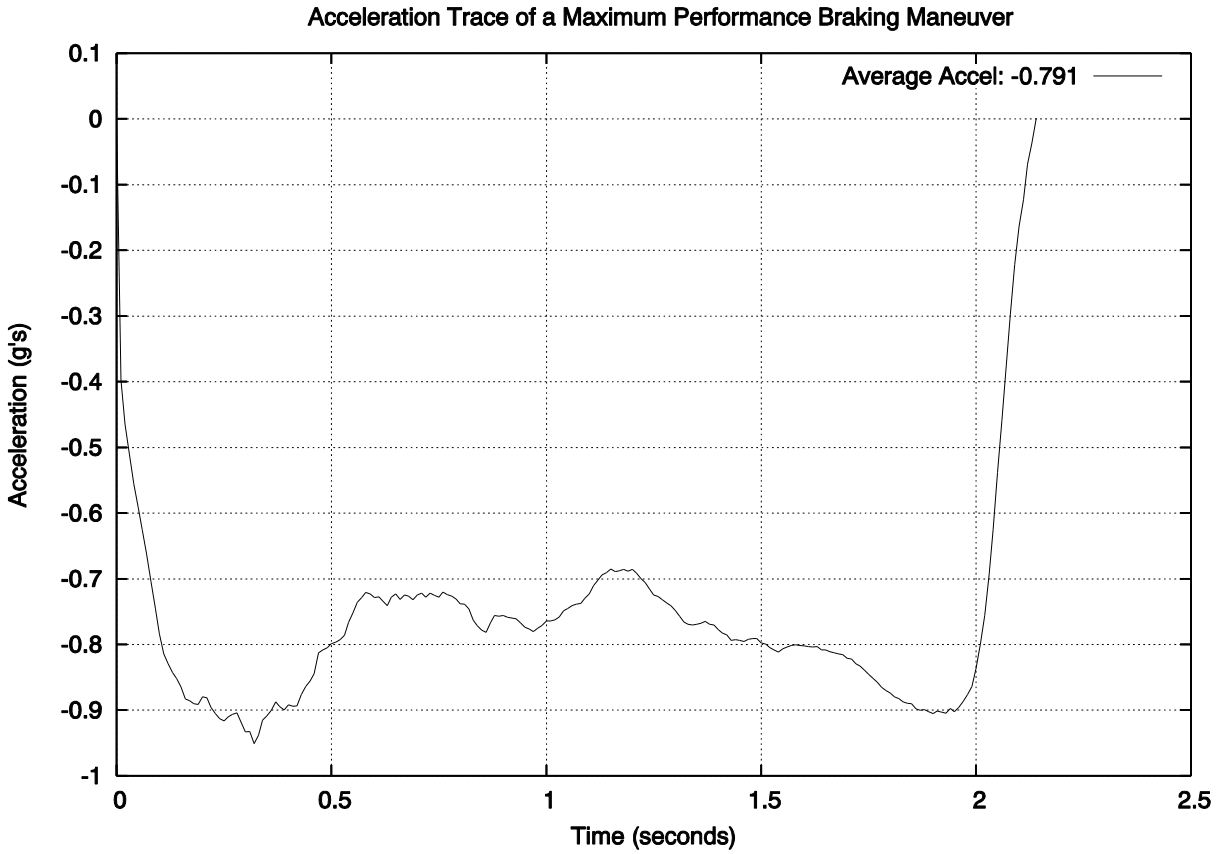

Figure 5: Typical acceleration trace for skid tests to determine the friction properties of a vehicle.

Table 1: Average accelerations for locked wheel skid testing.

	Run 1	Run 2	Run 3	Run 4	Run 5
Average Deceleration (g)	-0.791	-0.812	-0.789	-0.756	-0.804

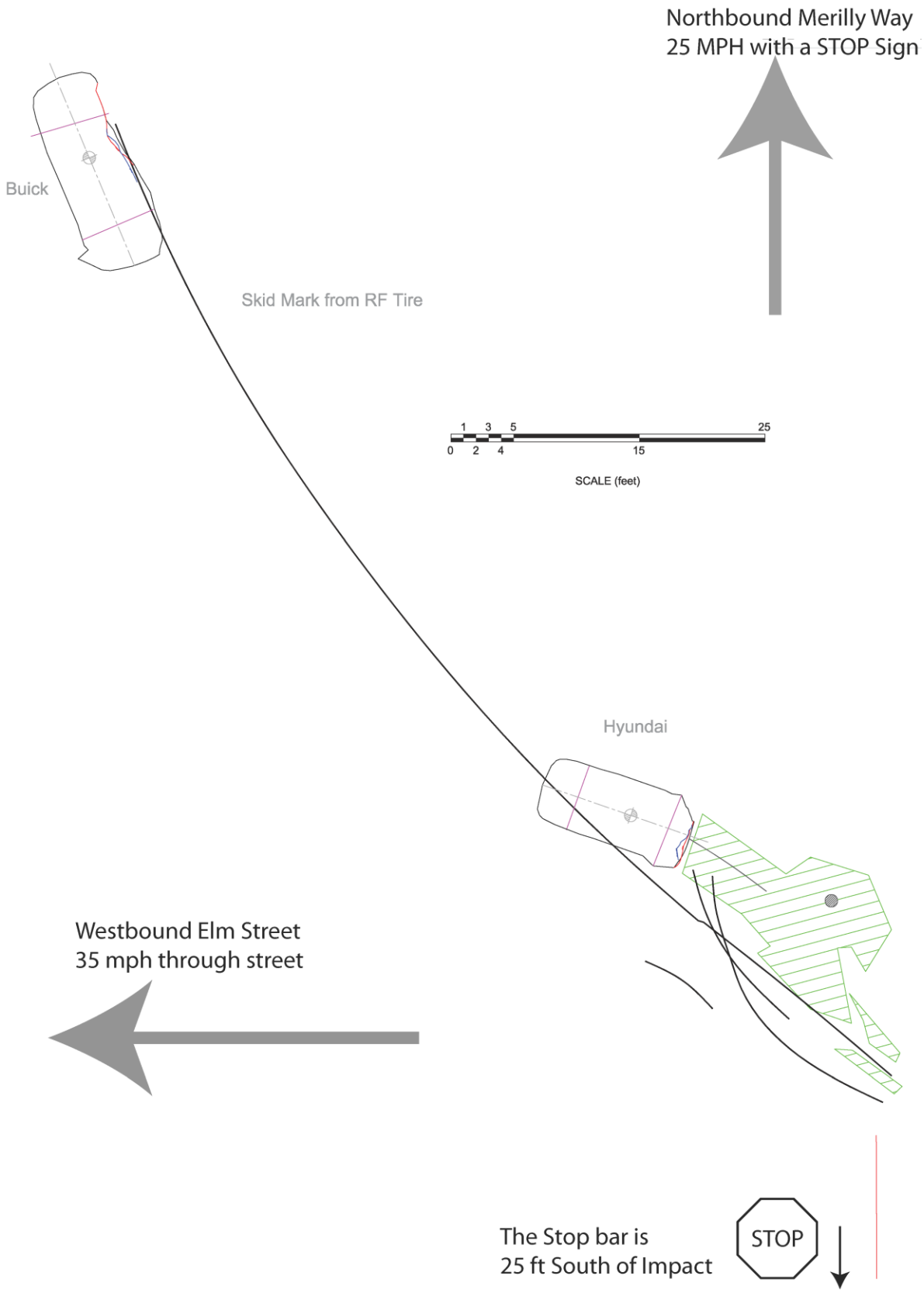

Figure 6: Scene diagram used for reconstruction.

Formative Evaluation

These expert witness role plays were videotaped and participants were surveyed about their experiences following the exercise. Across 3 years of Machine Dynamics, 48 Mechanical Engineering students participated in the deposition simulation. Formative evaluations consisted of a post experience survey that included quantitative and qualitative results. The quantitative data came from the following questions:

1. Did you enjoy participating in the deposition?
2. How useful was participating in the deposition?
3. Do you believe the deposition was representative of a real deposition?
4. Was communicating your analysis results verbally difficult?
5. Were you ever tempted to alter your analysis results to make you client look better?
6. Do you think the deposition was a worthwhile use of time for learning about the role of being an engineer and defending your work?

The enjoyment question was answered on a 5 point scale from *definitely not* to *definitely*. Students tended to enjoy the exercise with a mean rating of 3.94 out of 5 and a standard deviation of 0.78. Only one student rated the activity as unenjoyable (a 2 or *no* on the response scale).

The usefulness question was answered on a 4 point scale from *not useful* to *very useful*. Students tended to find the exercise to be a useful experience with a mean rating of 3.17 out of 4 and a standard deviation of 0.60. Five students were unsure whether was useful (a 2 or *unsure* on the response scale). While no students stated that is was *not useful*.

The representativeness question was answered on a 3 point scale including *no. maybe* and *yes* options. Students tended to find the exercise to be a realistic experience with a mean rating of 2.51 out of 3 and a standard deviation of 0.60. Eight students chose a fourth option, *I don't know*. While two students stated that it was not realistic.

The communication difficulty question was coded to a 2 point scale including *no* and *yes* options. Students tended to find the communicating their results to be somewhat difficult as 36/48 (75%) of the students indicated that it was not easy to communicate their results and methods to the lawyers.

The temptation to alter results question was answered on a 5 point scale from *definitely not* to *definitely*. Students tended to not acknowledge being tempted to alter their results with a mean rating of 2.10 out of 5 and a standard deviation of 1.02. However, 7 students stated that they were tempted (a 4 or *yes* on the response scale).

The worthwhile question was answered on 2 point scale including *no* and *yes* options. Almost all of the participants found the experience to be worthwhile (47/48; 98%).

The qualitatively reported advantages included hands-on experience and realism, while the disadvantages included not knowing if the results presented were actually correct and having only one member of the team give the testimony in the group version of the simulation. Some

participants found the experience to be scary, but most said that real-world pressure was good to experience.

Overall, the formative data shows that this role play approach was generally perceived as enjoyable, useful, representative of real world depositions, and worth the time and effort that it took to complete. It also provided a challenging opportunity for the students to try to present their findings to a non-expert in engineering with the added potential pressure of the temptation to alter results. While most students did not indicate feeling strongly tempted to alter their results, it is clear that the role play affords that possibility to the students. Overall this approach show potential as a pedagogical technique for teaching engineering ethics, but we need to evaluate the learning outcomes beyond reactions to understand the utility of this approach compared with other approaches.

An Initial Framework for Designing New Expert Witness Role Plays

We are developing a framework to aid other educators in developing expert witness role plays on additional engineering expert topics. This framework includes suggestions for roles and the necessary components to elicit ethical dilemmas in the expert witness role play. The initial framework for other teachers interested in developing and evaluating expert witness role plays in their own areas of expertise is a described below.

Based on the experience of using a role play scenario based on a vehicle crash, the following elements are likely necessary for construction of a scenario for use as an expert witness role play that trains engineering students how to recognize and deal with ethical situations.

- A relevant guiding document or philosophy on ethics from a professional engineering society should be provided to the students at the beginning of the exercise. For the example of the crash reconstruction scenario, the Society of Automotive Engineers has published J2314: "Ethics for Accident Investigation and Reconstruction" that is handed out with the assignment.
- The scenario should complement the course of study. In the case of a crash reconstruction, the course was machine dynamics and concepts of impulse and momentum are emphasized. The role play enhances the understanding of the technical content in the class.
- The legal outcome is not certain. The scenario should be designed such that both parties involved share some of the responsibility. The scenario should not invade the providence of a jury, yet require technical analysis to determine what actually happened.
- The engineering students should be "hired" by one side or another and then asked to help advocate for their side. This creates an ethical dilemma and temptation to modify the opinions rendered in a way that benefits the client.
- Students should render a written report that complies with legal standards. For example, Rule 26 of the Federal Rules of Civil Procedure describes the requirements for written disclosure by an expert witness. This written document also provides a basis for grading of the technical content.
- The authors of the written report should be deposed based on the opinions contained in their report. A mock deposition should involve students role playing the lawyers and experts. The sessions should be videotaped for future study and assessment.

Conclusion

The authors plan to continue to develop and evaluate new expert witness role play scenarios and formats to maximize the potential benefits of this pedagogy within the specific needs and constraints of different educational environments. The formative assessment of the expert witness role play approach appears promising, but it did not capture learning outcomes or comparisons with other approaches to teaching engineering education. Creative professors should be able to adopt this technique to teach engineering ethics within a realistic, engaging, and involving way.

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