IMPROVING DRIVING METRICS AND TRAINING STRATEGY THROUGH USE OF PERFORMANCE DATA

EXAMINING WHICH HIGHER EDUCATION ETHICS PROGRAMS IMPROVE ETHICAL CONSIDERATIONS IN ENGINEERS

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Systems Engineering

By
Damir Hrnjez

November 1, 2021

Technical Team Members:

Ryan Ahmadiyar,
Jenny Chun,
Caroline Fuccella,
Grace Parzych,
Benjamin Weisel

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISORS

Catherine Baritaud, Department of Engineering and Society

Brian Park, Engineering Systems and Environment

The past decade has offered an explosion in the amount of available data. All across academia, industries, and governments we are seeing more and more actors take advantage of data. The applications are limitless and can help firms hire new employees, stores optimize their spending, local governments develop safer emergency evacuation plans, and even individual people track their health data. Consequently, vehicles have also been touched by the gift of data. Cars are becoming more and more integrated into the internet of things, especially with a growing shift toward electric vehicles, which allows for easier tracking of their performance (Barla et al., 2017, p. 188). Actors can even retrofit older vehicles to allow for data collection through the use of small integrative technologies. This has unique value for large groups of vehicles such as the Facilities Management fleet of vehicles at the University of Virginia. With many vehicles in operation, optimizing economic and safe consumption can save money, time, and reduce environmental impact, especially on an aggregate level.

This technical report will monitor how safely and eco-friendly the Facilities Management fleet is driving with the goal of improving overall fleet performance in both of these categories. The study will be broken into three distinct parts. First, the team will research and analyze the right safety and eco-driving performance metrics as well as effective and ethical feedback training systems to administer to the fleet drivers. The second stage will entail administering the different training methods determined by the group and backed by previous research. Finally, the study will monitor driver performance in all determined categories for a duration of up to three months after training was delivered. For this study, eco-driving will mean driving that minimizes the fuel consumption of a vehicle. The first phase of the project will conclude by early November of 2021. The second part will be carried out throughout November and early December. The last phase will end in early March of 2022.

In cohesion with the technical project, this report will simultaneously explore a closely coupled STS topic: current engineering ethics training and best practices for future ethical and unbiased engineering curricula. This topic is relevant to the technical project because the technical project will involve the design and implementation of a training system based on real-time performance metrics. A growing problem with the rise of data is the development of biased and unethical recommendations and algorithms based on that data that are self-reinforcing and can have devastating consequences on the end-users to which these technologies are applied (O'Neil, 2018). Proper training for engineers is imperative in the future to minimize the negative effects that big data presents.

IMPROVING DRIVING METRICS AND TRAINING STRATEGY THROUGH USE OF PERFORMANCE DATA

The technical portion of this report attempts to address both important driving metrics for safe and eco-driving as well as best training practices and strategies to ensure that fleet drivers are driving safely and in an environmentally friendly way. Vehicle safety is critical for the drivers of a fleet but also for the community around which the vehicles operate. Unnecessary accidents, and in extreme cases, deaths can be avoided by promoting safer driving and ensuring drivers know and maintain safe driving practices. Vehicle accidents can also incur significant costs to a fleet even if injury does not occur. Environmentally conscious driving is also important for a fleet to implement due to the increasing threat of global warming and need for more sustainable practices. Ensuring that fleet vehicle drivers know proper eco-driving techniques can help significantly reduce a fleets carbon footprint. A study by Huang et al. (2018) claimed that eco-driving is even more cost-effective with more immediate results than fleet retrofitting and can have up to 45% improvement in fuel efficiency (p. 597). As a result, this study aims to demonstrate an effective way to promote safe and eco-driving in fleet vehicle drivers. More successful trainings will see the longest lasting effects.

Brian Park, a professor in the Department of Engineering Systems and Environment at the University of Virginia, will serve as the technical advisor for this report, offering his transportation expertise and guidance in the experiment design and analysis process. Park is aided by Engineering Systems and Environment graduate student Zeyu Mu in advising the team. Fleet manager Michael Duffy will also work closely with the team as a representative for the client Facilities Management department. He will help the team with any needed information and access to the Facilities Management vehicle shops. The team itself will be made up of six undergraduate systems engineering students: Ryan Ahmadiyar, Jenny Chun, Caroline Fuccella, Graze Parzych, Benjamin Weisel, and myself.

The technical report of this paper will consist of extensive preliminary research broken into two categories followed by data analysis on driver performance metrics with the goal of answering two research questions. The first research category revolves around determining the proper safe and eco-driving metrics to monitor the fleet vehicles with. The second research category will focus on determining the right training strategies to implement on the fleet drivers. The team will administer trainings on selected shops of vehicles from the overall fleet in order to determine how long the effects of safe and eco-driving training last and which specific training method has the most effective results. It is important to distinguish that the experiments and data collection will not be done on individual drivers but rather specific vehicles to which an unknown number of drivers might be assigned. This consideration is to ensure no individualized monitoring and that the project is in accordance with the requests of the Facilities Management team leadership. The report will serve as a proof of concept for best training practices to ensure safe and eco-driving in large vehicle fleets. The findings of the entire report will be published in a conference paper for the SIEDS forum in the spring of 2022.

The team will work with a small subset of vehicles from the overall Facilities Management fleet, and anticipates working with 5 different treatment groups in order to answer the technical research question. There will be one control and four other groups that receive a variation of different training methods. The methods will include a developed training module from a previous year, bi-weekly scorecards, and shop-wide conversations with supervisors. Given that there is a lot of variability in road conditions, drivers, and routes, we will look at data from similar vehicles to ensure some homogeneity. The team will monitor each vehicle's performance through the use of a technology called Geotab. This is a small device, that the Facilities Management installed on all of its vehicles, known as a data logger. Huang et al. (2018) explains that data loggers are relatively cheap and easy-to-install devices that can monitor driver performance directly on the road. They can collect vehicle speed, engine speed, fuel consumption, GPS, and emissions data. These devices are also small so their installation does not affect performance results. Their small size also makes it easier to use on a wide array of vehicles (p. 602). Summary data from Geotab on specific vehicles will be recorded in scorecards such as seen in Figure 1 below. These are summaries of the data and therefore different from the scorecards that the team will develop as part of training.

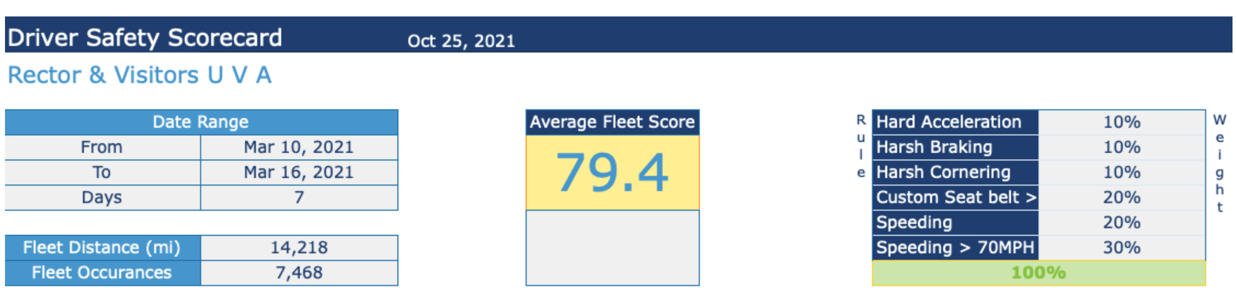

Figure 1: Driver Safety Scorecard from Geotab data logger. (Hrnjez, 2021)

After the trainings are administered to each group, the team will continue to administer their own developed score-cards on a bi-weekly basis and monitor the fleet's performance for up to three months. The use of statistical tests, such as analysis of variance, will allow the team to distinguish which treatments were the most effective and for how long.

EXAMINING WHICH HIGHER EDUCATION ETHICS PROGRAMS IMPROVE ETHICAL CONSIDERATIONS IN ENGINEERS

This report relies on the use of data in order to make informed decisions and improvements on safety and environmental impact in a fleet of vehicles. The data will continuously monitor real drivers and report their performance on a bi-weekly basis. While there will not be any data tied to a specific individual, driver performance will indirectly be observed. This pattern of observation is very common today as is the use of data to create programs, algorithms, and judgement calls on a regular basis (O'Neil, 2018). Because such practices are so recent and because engineering education has historically not stressed the value of ethics, there has been a disconnect between engineering design of such technologies and their consequences on users. For example, companies and governments use of algorithms has led to racist policies and practices. Rise of journalistic reporting on these issues has further emphasized the need for change (Joyce et al., 2018, p.2). As a result, this report is closely coupled with an STS analysis into engineering education and specifically which training is best to ensure ethical and unbiased practice in engineers. This research question attempts to analyze an ongoing controversy and is relevant because of the lack of existing engineering education all across the board. There is not a cohesive curriculum that all universities use; instead, as Joyce et al. explain, many universities administer online ethics modules in order to maintain their ethics requirement for accreditation. Such systems are not effective and there needs to be more robust and authentic ethics education given to engineers (p. 3) The research for this report will look into specific examples of ethics curricula as well as what leading STS scholars argue is the best solution.

The design of engineering ethics education will be treated as a technology in this report and therefore will be looked at with two distinct STS frameworks. First, the report will use the Social Construction of Technology framework as developed by Trevor Pinch and Wiebe Bijker (1984) to explore the role of different actors in the development of the curriculum. Their framework fits best with this research question because it explores how technology is developed through a social lens. Education is inherently a very social and interactive process. They also offer a variety of diagrams, such as seen in Figure 2 below, that simplify the understanding of the relationship between artifacts and social groups. In Figure 2 we see how their theory can be applied in the case of this example, where the relevant social groups are in the boxes surrounding the central box, which is the technological artifact.

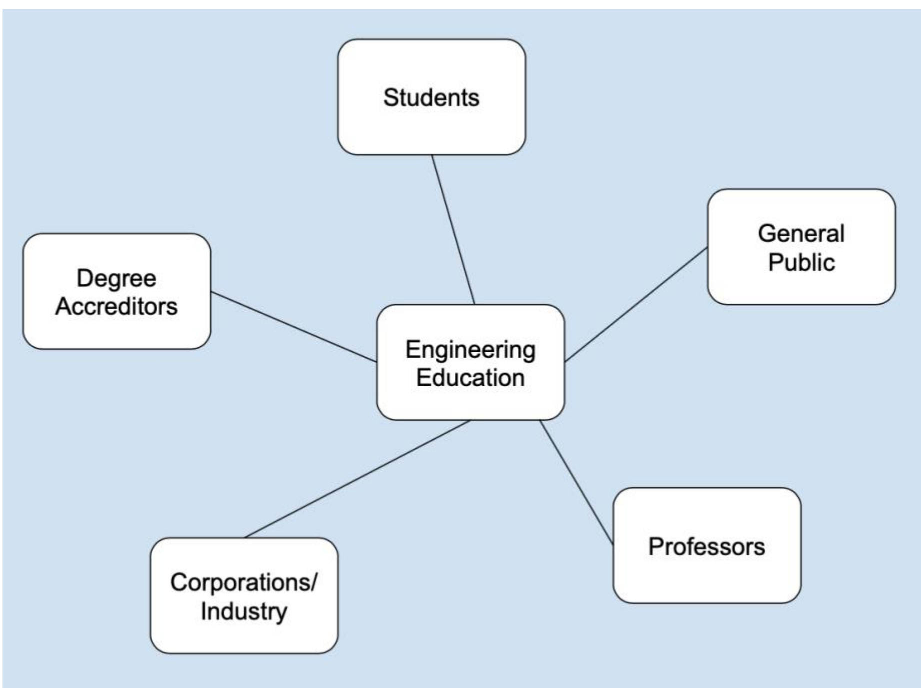

Figure 2: SCOT model of relevant social groups to engineering education. (Adopted by Hrnjez (2021) from Bijker, Pinch, 1984)

Currently, as Jeske (2020) highlights, ethics has always been regarded as an external part of the engineering design process because the conversation is dominated by one elite group (p. 310). Jeske adds to this that in order for ethics to become more integral in engineering design, the conversation around it has to bring in more actors and as a result more technologies and sectors (p. 310). The interpretive flexibility of engineering education, or social influence on the meaning of the technology, as defined by Bijker and Pinch (1984), will change and adapt to more users that are affected by it. SCOT is useful here because it can help to better understand what meanings a technology can employ. Jeske uses a specific example, the failed blood-test company, Theranos, created by Elizabeth Holmes, to emphasize that such failures should not be looked at as the consequence of an individual bad actor, but as an ethical failure of an entire system (p. 309). The system in question is the bioengineering and bioethics industry, which is just one example of how failures in higher academia can lead to ethical disasters down the line. Jeske argues that by only placing agency on Holmes for the scam she created, we fail to improve ethics education in academia and industry. This is because we fail to consider the unethical, profit driven motivations that are increasingly mixing with higher education (p.311). SCOT analysis will allow for examination of these other actors to come more readily.

The engineering education research will also be closely related to the Carslon/Baritaud social construction model (Carlson, 2009). This framework is relevant because the design of engineering education, much like the design of new technologies, should be created with continuous two-way feedback between the designers, end-users, and social groups. Figure 3, found on the page 8, demonstrates the core principle outlined in this model. In the figure we see universities as one of the social groups with which engineering education designers must interact with. However, there are many more groups that this report will consider.

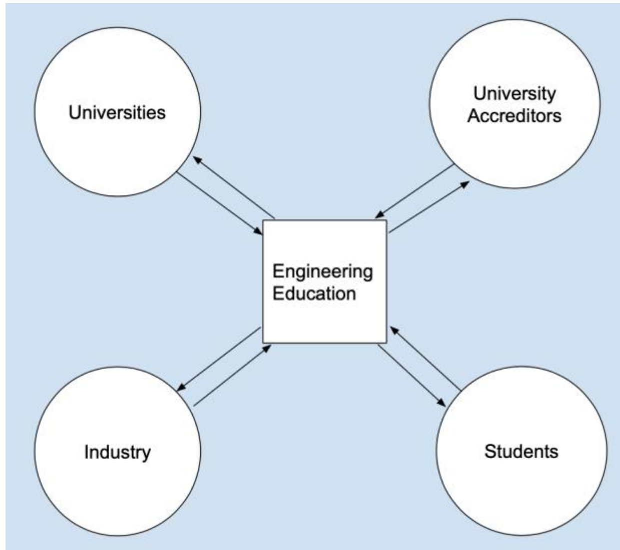

Figure 3: SCOT model of social construction of engineering education. (Adopted by Hrnjez (2021) from Carlson, 2009)

In line with the model, research will attempt to identify the relevant social groups and how each group interacts with the technology's design and designers. Furthermore, the unique role of universities will be considered as a designer and tradeoffs in different design elements will be explored. A case study example, led by Sunderland et al. (2014), offers some initial insight into the importance of feedback and many voices in the design of ethics education that led to the use of this model. Doing so will allow ethics to become more embedded into the core of engineering curricula and not just the periphery (p. 228). Sunderland et al. created a pilot program to back their claim. *Global Perspectives: Engineering Ethics Across International and Academic Borders* was a pilot educational program administered on graduate students in order to facilitate discussion about ethics in engineering from multiple perspectives and fields. The program was given to students from University of California, Berkeley and Delft University of Technology (p. 229). The authors of the program relied on teaching emotion-driven ethics as it improved student engagement and empathy toward the issues. Student engagement was considered a combination of how much time and effort students put into their own education as well as how much time and resources educational institutions put into their students. As a result, developing a proper engineering ethics curriculum relies on student input (Sunderland et al., 2014, p. 230). Their pilot course also demonstrated the importance of collaboration between engineers and those in other fields. Placing everyone on the same level and allowing for open discussion places engineers in a position to actively discuss where there are holes in ethics education (p. 236).

Given the research and case studies employed by STS scholars, the goal of this STS research question is to evaluate the best practices for teaching engineering ethics in higher education. SCOT will allow for uncovering the relevant social groups associated with each suggested curriculum and how they will progress. The results will be unique and serve as a possible solution that can be explored further and tested in the future.

COMBINING THE EVALUATION OF TWO DIFFERENT TEACHING PROGRAMS

The two components of this paper, technical and STS, will serve to uncover training strategies for fleet vehicle drivers and managers and for those developing engineering curricula. The former will rely on employing actual data collection and analysis in order to experimentally measure which strategies are the best. The latter will use existing research on engineering curricula and similar programs in order to uncover the best solution. In addition, the STS discussion will depend on two frameworks that will allow for better understanding and judgement of the various methods presented in past research. The findings of both reports will be novel and important for furthering vehicle fleet performance as well as ethics amongst engineers, respectively. Proper fleet management is necessary in order to optimize on performance and decrease cost and emissions. Engineering education is in need of properly taught ethics in order to ensure the design and integration of future technologies can benefit society correctly.

REFERENCES

Barkenbus, J. N. (2010). Eco-driving: An overlooked climate change initiative. *Energy Policy*, *38*(2), 762-769. https://doi.org/10.1016/j.enpol.2009.10.021

Barla, P., Gilbert-Gonthier, M., Lopez Castro, M. A., & Miranda-Moreno, L. (2017). Eco driving training and fuel consumption: Impact, heterogeneity and sustainability. *Energy Economics*, *62*, 187–194. https://doi.org/10.1016/j.eneco.2016.12.018

Bijker, W.E., & Pinch, T.J. (1984). SCOT model of relevant social groups to engineering education. [Figure 2]. The social construction of facts and artifacts. *Social Studies of Science*, 14, 399-441.

Bijker, W.E., & Pinch, T.J. (1984). The social construction of facts and artifacts. *Social Studies of Science*, 14, 399-441. https://doi.org/10.1177/030631284014003004

Bucciarelli, L. L., & Drew, D. E. (2015). Liberal studies in engineering – a design plan. *Engineering Studies*, *7*(2-3), 103–122. https://doi.org/10.1080/19378629.2015.1077253

Carlson, B. (2009). SCOT model of social construction of engineering education. [Figure 3]. *Class handout* (Unpublished). School of Engineering and Applied Science, University of Virginia. Charlottesville, VA.

Delhomme, P., Cristea, M., & Paran, F. (2013). Self-reported frequency and perceived difficulty of adopting eco-friendly driving behavior according to gender, age, and environmental concern. *Transportation Research Part D: Transport and Environment*, *20*, 55–58. https://doi.org/10.1016/j.trd.2013.02.002

Foley, R., & Gibbs, B. (2019). Connecting engineering processes and responsible innovation: A response to macro-ethical challenges. *Engineering Studies, 11*(1), 9-33. https://doi.org/10.1080/19378629.2019.1576693

Harvey, J., Thorpe, N., & Fairchild, R. (2013). Attitudes towards and perceptions of eco driving and the role of feedback systems. *Ergonomics*, *56*(3), 507-521. https://doi.org/10.1080/00140139.2012.751460

Hrnjez, D. (2021). Driver Safety Scorecard [Figure 1]. *Prospectus* (Unpublished undergraduate thesis). School of Engineering and Applied Science, University of Virginia. Charlottesville, VA.

Huang, Y., Ng, E. C. Y., Zhou, J. L., Surawski, N. C., Chan, E. F. C., & Hong, G. (2018). Eco driving technology for sustainable road transport: A review. *Renewable and Sustainable Energy Reviews*, *93*, 596–609. https://doi.org/10.1016/j.rser.2018.05.030

Jeske, M. (2020). Lessons from Theranos: Changing narratives of individual ethics in science and engineering. *Engaging Science, Technology, and Society*, *6*, 306-311. https://doi.org/10.17351/ests2020.411

Joyce, K.A., Darfler, K., George, D., Ludwig, J., & Unsworth, K. (2018). Engaging STEM ethics education. *Engaging Science, Technology, and Society, 4*(1), 1-7. https://doi.org/10.17352/ests2018.221

Klein, J. D. (2015). Teaching and learning limits in engineering education. *Engineering Studies*, *7*(2-3), 135–137. https://doi.org/10.1080/19378629.2015.1062494

O'neil, C. (2018). *Weapons of math destruction: How big data increases inequality and threatens democracy*. Penguin Books.

Sunderland, M. E., Taebi, B., Carson, C., & Kastenberg, W. (2014). Teaching global perspectives: Engineering ethics across international and academic borders. *Journal of*

Responsible Innovation, *1*(2), 228-239. https://doi.org/10.1080/23299460.2014.922337

Tanvir, S., Chase, R.T, & Roupahil, N. M. (2019). Development and analysis of eco driving metrics for naturalistic instrumented vehicles. *Journal of Intelligent Transportation Systems*, *25*(3), 235-238. https://doi.org/10.1080/15472450.2019.1615486

Tomblin, D., & Mogul, N. (2020). STS Postures: Responsible innovation and research in undergraduate STEM education. *Journal of Responsible Innovation*, *7*(sup1), 117-127. https://doi.org/10.1080/23299460.2020.1839230