EMERGING TECHNOLOGIES
RESEARCH BRIEF | JULY 2024

AAA FTS
FOUNDATION FOR TRAFFIC SAFETY

Consumer Education and Training for Vehicle Automation: Outcomes from an Expert Workshop

Advanced in-vehicle technology is becoming more commonplace in the U.S. passenger vehicle fleet. Under limited circumstances, driver support features such as adaptive cruise control (ACC), lane centering assist (LCA), and other forms of vehicle automation can now perform parts of the driving task. It follows that these features can change drivers' roles, including adopting passive system and environment monitoring strategies and the ability to physically disengage from portions of the driving task. While intended to promote driver comfort and convenience, while maintaining reasonable levels of safety, these features are complex and currently have a number of important limitations that govern their appropriate and safe use. For example, some systems have limitations in adverse weather or road surface conditions, in situations of high glare, or other circumstances.

Encouraging driver understanding of technology constraints may help mitigate overreliance on the technology and other challenges when encountering hazards. Unfortunately, drivers may exhibit poor understanding of their roles with respect to driving automation, which may in turn influence appropriate use (McDonald et al., 2018; Lenneman et al., 2020; Mason et al., 2023). Ultimately, the goal is to promote appropriate use of technology and consumer education is just one means to that end. Methods to improve understanding through education and through human-machine interface design have been the subject of recent studies (e.g., Carney et al., 2022, DeGuzman et al., 2022; Mehrotra et al., 2022; Pradhan et al., 2023; Wang et al., 2023).

In partnership with:

CSRC
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CONSUMER EDUCATION (CE) WORKSHOP

To advance these research discussions, a workshop was organized by the AAA Foundation for Traffic Safety (AAAFTS), the Toyota Collaborative Safety Research Center (CSRC), and the University of Wisconsin–Madison. The one-day workshop was hosted in May 2023 on the University of Wisconsin campus and convened 21 invited individuals from academia (10), research organizations (5), industry (2), government (1), and advocacy organizations (3). The purpose of

the workshop was to hold interactive discussions to inform consumer education (CE) research and help advance science and knowledge in this space (see Figure 1 for an overview of the day's exercises). This summary report provides a high-level overview of some of the outcomes of the three main workshop exercises.

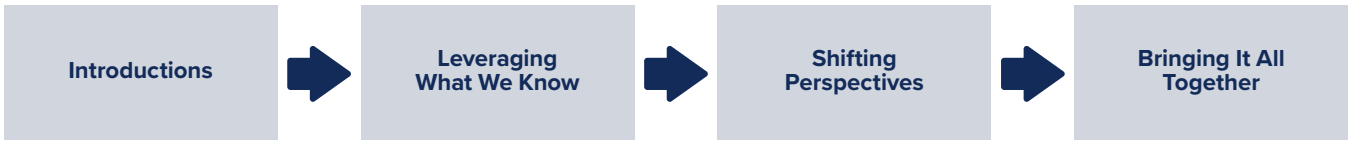

Figure 1. Overview of the workshop.

LEVERAGING WHAT WE KNOW

Following roundtable introductions and brief perspectives on the topic, attendees were divided into two groups to discuss opportunities to apply and leverage what is collectively known in this space. One group focused on implementation by CE developers and other stakeholders. The other group focused on research, including the current state of research findings, remaining gaps, and more. Groups switched topics midway through the exercise. The general guidance provided to participants is shown in Figure 2.

Implementation

- What are some good examples of CE approaches? What works? Why?
- Any approaches that others may not be aware of? International? Unique stakeholder?
- What is the scope of CE? Is there, and where is the line of delineation between CE and training? How much overlap?

Research

- What is the research already being conducted?
- How would you label/classify* CE research as it's been conducted so far?
- What are the fruitful areas? What research topics do you anticipate (or are already seeing) high return on investment (ROI)?
- Where are the gaps?

Figure 2. Questions used to spark discussion on current knowledge and practices.

Implementation

The groups noted some successes in adjacent safety areas for getting key messages to motorists. These included "click it or ticket" campaigns as well as campaigns for parents to move children to rear seats where they receive more crash protection. These were very simple messages with little ambiguity, although the groups noted that advanced driver assistance systems (ADAS) and automation were more complex and therefore challenging, especially without system standardization. The groups also noted some successes with the application of virtual reality approaches, where users could be given direct experience without compromising safety (e.g., Riegler et al., 2021; Sportillo et al., 2018). They also noted some success or appeal from approaches in the current context where systems are branded or framed as being more assistive (or guardians) as opposed to autonomous (or chauffeurs).

The balance of the discussions tended to lean towards challenges or key considerations

for the implementation of consumer education and training. These included the following:

- **Timing:** What and when are the critical touchpoints for conveying information to drivers? Many touchpoints were discussed, including at the point of sale, during service appointments, or while refueling/recharging.

- **Prevention:** Is it possible, and how can CE efforts effectively intervene during the time period when bad habits are developed? That is, early, within the first few hours in order to target bad habits in formation.

- **Messaging:** How to get the tone of the messaging right? The groups noted that some marketing approaches could theoretically exacerbate system misunderstanding by using messages and examples to influence consumer purchasing behavior rather than driving behavior. Although the marketing efforts may be entirely accurate and appropriate, it is not possible to ensure that recipients of the message have the same contextual understanding of what is being messaged and also understand associated system limitations. In contrast, messages seeking to promote safe, responsible use of driver assistance and vehicle automation systems might focus on side-by-side comparisons various systems' performance and/or limitations.

- **Delivery:** What are the best delivery channels or medium for messaging or training? The effectiveness of different delivery channels or mediums might vary due to technology differences, individual differences of the learner, or many other reasons.

- **Tailoring:** How to design CE to fit the unique learning preferences and styles of individuals? Variation can overcome challenges to aligning CE with individual characteristics, leading to high engagement and retention.

The groups stressed the importance of collaborations with respect to education and training for vehicle automation, with many stakeholders represented, ranging from system designers to researchers and government. Regarding implementation, an analogy to an exhibit inside of a museum was shared: this problem requires a consideration of how to get people in the museum to engage with the exhibit, but it is also important to consider how to entice people to come to the museum in the first place. A multitude of CE approaches can be employed in a manner that exposes the user to multiple opportunities to engage across the lifespan of the technology (and not just focused on the initial interactions). By increasing the number of touchpoints, there is a greater chance to engage users (i.e., get them into the museum).

Research

The groups emphasized some inherent challenges related to research on consumer education and training on vehicle automation. Foremost was the understanding that the time between tech development and publication of scientific research was significant, challenging the ability to inform policy and development with research in this environment. Similar to the implementation topic described above, the groups endorsed increased collaboration between stakeholders to support dialogue. Collaborations can be multifaceted, including raising awareness and prioritizing research needs or actions, facilitating or coordinating a more efficient implementation, and working to ensure funding or support for priority areas, among others.

The groups also discussed (though did not go as far as to resolve) nuances between what constitutes CE versus training and learning. Training might be considered a structured way of translating information, whereas CE provides resources/content, and learning is largely approach-driven. These perspectives notwithstanding, potential confusion over these

concepts exists. Further work and dialogue to delineate them more clearly is merited.

The groups also entertained many different research topics or questions that merited attention:

- **CE and Technology Calibration:** Determining the appropriate alignment of detail in education with the specific system that driver is using (generic versus specific).
- **Over-the-Air (OTA):** Explore challenges associated with OTA updates and subscription models for vehicle features (e.g., features can lapse if expired).
- **Vehicle-Integrated CE:** Leveraging the human-machine interface (HMI) to support information and education. For example, real-time embedded training (e.g., Clippy the Office Assistant in older versions of Microsoft Word) and contextualized information based on traffic/driver/system states.
- **Format and Timing:** Core questions about how, when, where, what, and whom of training? For example, just-in-time training as opposed to front loading or providing unnecessary information (e.g., information about optional features not equipped on a given vehicle). Can we support typical user patterns of trial-and-error to make the process safer and more constructive?
- **Advertising:** Measuring whether or to what extent advertisements influence consumer understanding.
- **Social Norms:** Examining the impact of social norms and behavioral intentions on acceptance of CE, learning and knowledge retention, translation of CE to actual use, etc.
- **Training Approaches:** Evaluation of different training approaches, including active learning/training, error-based training, responsibility-based versus feature-based training, information-only versus hands-on practice, etc.
- **Gamification:** Examine gamification in promoting learning (e.g., earning points or unlocking new features as segments of training are completed).
- **Mental Models:** Examine resilience of mental models over time and in light of different CE or marketing approaches.
- **Errors in CE:** Impact on drivers (e.g., mental models, use) of exposure to false information or other things (e.g., media, advertising).
- **Tailoring CE:** Identifying the appropriate medium for different populations (e.g., targeting young drivers via CE embedded in Instagram, etc.).
- **Driver Monitoring:** Examine the utility of driver state monitoring (DSM) as means to verify appropriate knowledge or practice.

SHIFTING PERSPECTIVES

The second breakout activity asked that groups consider different users' or stakeholders' points of view, including developers (designers), policy makers (advocates), researchers, and end users (see Figure 2). The central question was what these stakeholders would say needs to be done to benefit them (i.e., trying on "different shoes"). For example, they considered

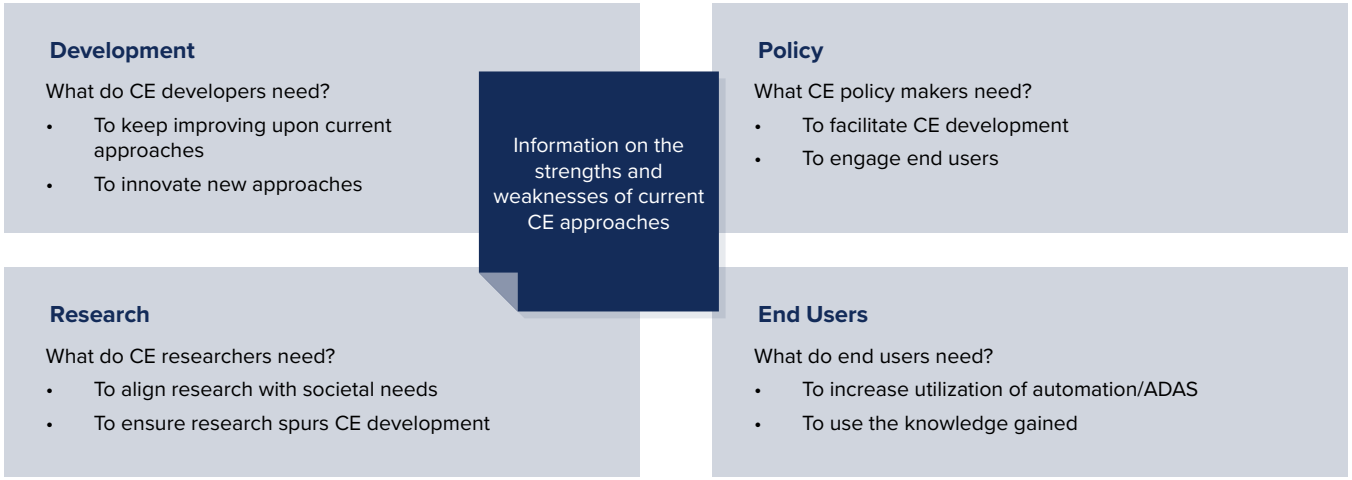

Figure 3. Different perspectives covered in the second group exercise, along with some questions intended to spur thinking and dialogue.

what system or CE developers would need to improve upon current practices or to innovate new approaches (see Figure 3). The topics were rotated throughout the exercise so that each group considered all the different perspectives.

Development

The groups were asked to consider, "What do developers need to improve current or create new, impactful CE approaches?" A number of needs related to product development were highlighted:

- Clarity on the different stakeholders in the consumer education and training development process (e.g., engineers, marketing, etc.).
- Infrastructure and tools for connecting information as well as stakeholders/groups. This includes tracking information through to end users.
- Focus on data and results, including confirmation that problems perceived by the different stakeholders are actual problems, reflected in underlying real-world data.
- Individuals who can facilitate application of information across stakeholders in the development process (e.g., human factors to engineering, driving instructors, safety evangelists).
- Further discussion of whether standardization is appropriate and useful for elements of CE, within and across original equipment manufacturers (OEMs).
- For developers of systems to have comprehensive knowledge of the systems for which CE approaches are developed.

Policy

The groups were asked to consider, "What do policymakers need to write policy that facilitates consumer understanding and safe, efficient technology utilization?" A number of different needs were discussed in support of policymakers, including the following:

- Development of a conduit of data and information for policy makers that is actionable.
- Encourage policymakers to experience automated systems prior to creating policy.

- Facilitate narrowing the gap between immediate challenges by OEMs and the current state of research.
- Identification of the best ways to engage users (e.g., used to be radio, but the landscape has shifted. YouTube & TikTok? Billboards? Variable message signs? Possible integration with navigation system to report problems?).
- Ensure that policy is sufficiently robust to accommodate system updates.

End Users

The groups were asked to consider, "What do users need to help ensure technology understanding and safe, efficient technology utilization?" Regarding the end user (i.e., driver using automated vehicle technology), the groups raised a number of issues or needs. These included the following:

- An ideal or a tailored medium for the messaging, considering different approaches for different audiences. This includes special populations.
- Appropriate timing of information (e.g., post-drive videos or feedback) and how information is sequenced or serialized (layered).
- Consideration of the tenets of Universal Design, but with understanding that information might need to become more focused on specific systems (i.e., balancing general versus individualized feedback).
- Continued respect of users in how training is offered. This includes the philosophy of "opt in" versus "opt out."
- Minimizing burden on users to understand systems.
- Balance feedback to increase understanding with the risk of fostering system over-reliance.
- Clear hooks to motivating factors: Comfort, safety, convenience, accessibility, etc.
- Consideration of connecting training with other tangible benefits to drivers, such as reaping insurance benefits if drivers become "certified" on their own vehicles.

Research

The groups were asked to consider "What does the scientific community need [in order] to produce knowledge leading to effective CE solutions?" Several issues and needs were identified. These included facilities to support research, research topics (with some overlap with the previous exercise), as well as communication and coordination among stakeholders. Specific needs included the following:

- A continuous and adequate funding stream.
- Insight from industry to keep researchers on track and relevant.
- Research to link design decisions to real-world consequences, analyzing pros and cons for certain design elements (e.g., touchscreen versus traditional/physical controls).
- Understanding of net safety benefit of ADAS and the relationship with decisions to use technology.
- Examine the relationship between initial learning and long-term feedback, and the association with other factors, such as trust.
- Avenues for new data, including near-miss reporting related to ADAS and automation. This could be built into navigation and voice commands to make it easier to report.

- More research on application of knowledge. That is, knowledge of the system versus use of knowledge in the moment.
- Expanded network of collaborators, including stakeholders from pedagogy, instructional design, marketing, and survey design.

Additionally, there should be more outreach and interactions with the public (all ages).

- Increased coordination and communication across institutions regarding ongoing efforts to help avoid unnecessary duplication.

BRINGING IT ALL TOGETHER

At the conclusion of the two exercises, the whole group was convened in order to bring all the discussion points together into one final exercise. The crux of this exercise was to entertain the question of what activities, relationships, and resources are needed to ensure that we are ready to educate users of future technologies. Each person volunteered one point, building on what others had already shared.

To ease discussion, the variable topics or themes raised by the group were arranged into broader categories, as discussed below. We also endeavored to represent the discussion in a graphical framework, which is shown in Figure 4. Throughout this section, underlined text reflects the keywords offered by the workshop participants.

Non-User Stakeholders

In general, non-user stakeholders included the research community, the designers or developers and marketing groups from OEMs, government entities and policy makers, as well as automobile dealerships (shown at bottom of Figure 4). Though also a stakeholder, the operator (i.e., driver) was considered separately. The needs/topics/themes that related to this stakeholder group included the following:

- Communication between stakeholders and end users, including knowing how end users perceive and use systems and what they have trouble with.
- More sharing of ideas and updates among research community and other stakeholders (under the guise of meta-research).
- Consider and adopt multidisciplinary approaches (different perspectives) to address issues.
- Need for shared and accessible resources, including access to the state of the art for researchers and consumers having access to training when they need it.
- Need for stakeholders to continue to consider alternative perspectives and needs (i.e., putting themselves in others' shoes).
- Design systems to afford and promote appropriate use by operators.
- Balance between marketing approaches and appeals for safety.
- Promotion of vehicles and technology more as a guardian (versus chauffeur).
- Understanding that words matter, that information needs to be communicated to consumers/drivers effectively and accurately.
- Emphasizing respect for the user, and not overestimate or underestimate their capabilities.

- Map business cases to key dimensions to prioritize resource allocation and to evaluate return on investment.

Operator

A few of the themes related to the end user or operator in the system (see top of Figure 4):

- Consider the motivation for the operator to take training or educational offerings (this can also encompass behavioral intentions and social norms).
- Consider generational differences in learning preferences, including the sources, habits, etc.
- Keep all users in mind, over the life of the vehicle and not just the person who buys from dealership (e.g., used car market, rentals, other members of owner/purchaser's household).

Training

Many keywords related to the training itself and related to the content, the medium or format, and the timing or frequency of the training. The issues are distilled and reflected in the central portion of Figure 4. These included the following:

- Need to scale education across the diversity of implementations, considering contextual factors and specific systems.

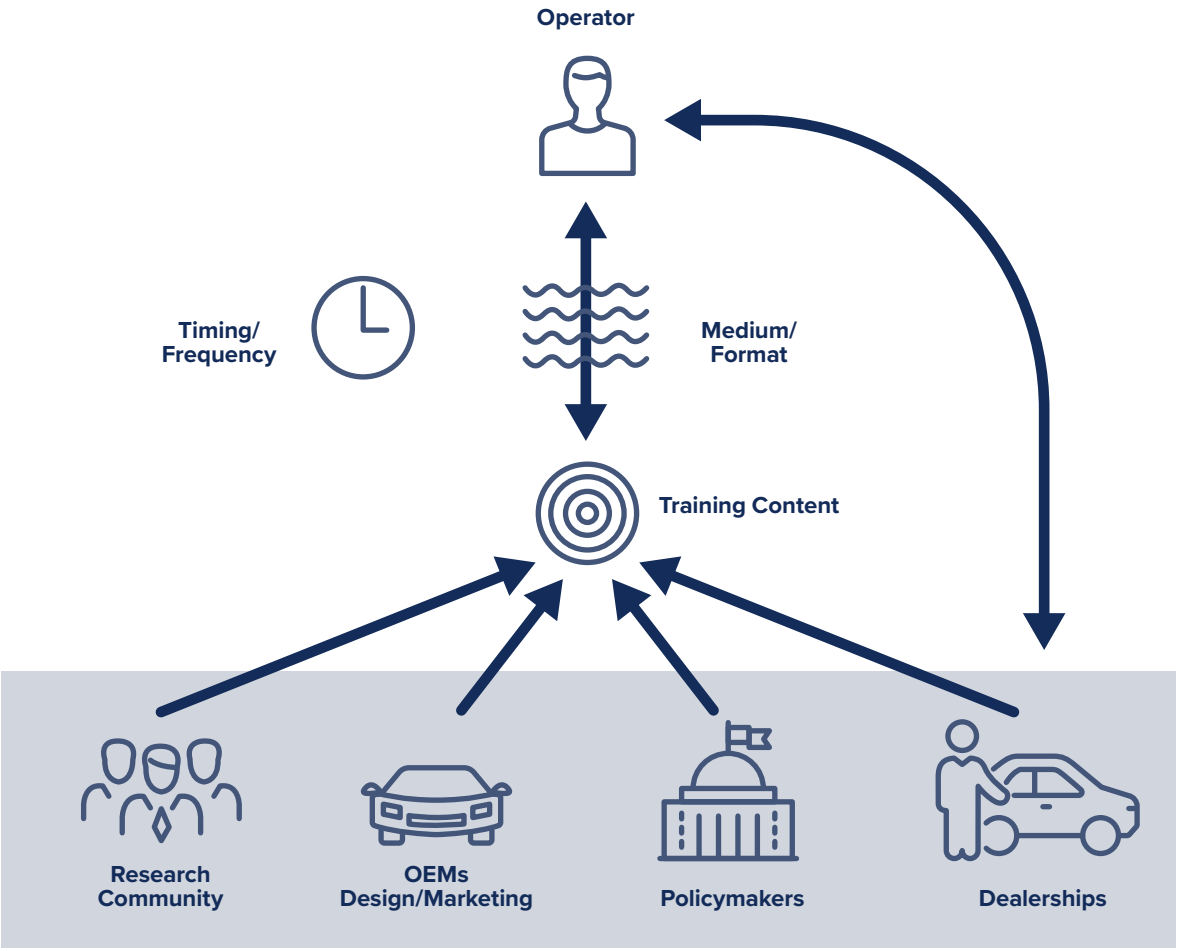

Figure 4. Graphical representation of a framework of the necessary elements to educate users of advanced and future technology.

- Content of education or training needs to balance specific versus general system information.
- Adoption of prototype learning versus exemplar concept could help generalize to systems/situations or aid in understanding of underlying technology.
- Education/training and design efforts need to work together (i.e., a chicken and egg situation).
- Approaches can encompass multiple touchpoints to various end users throughout their lifetime (or the vehicle lifetime) and/or tailored by use of vehicle data (e.g., what systems have been used).
- Need to provide more support or scaffolding while training/educating operators.
- Need to figure out the information that someone needs at the time that they need it (i.e., just-in-time) with responses being contingent upon use-case scenarios.

CONCLUSION

New and advanced in-vehicle technology is increasingly offering support for driver comfort, convenience, and safety. However, these complex systems may not be well-understood by drivers, which could lead to unintended consequences, especially if the systems are used in situations for which they were not designed. The purpose of this workshop was to bring together stakeholders from academia, industry, government, and advocacy groups to discuss recent developments and perspectives on topics germane to consumer education and training on driving automation systems. The groups started with the common belief that stakeholders have been working diligently to properly educate consumers and minimize attendant risks with these new technologies. The focus of this group was to review the present situation, objectively, and discuss how the current efforts are working and where efforts might be directed to provide additional benefits and increased efficiency, as well as try to identify new CE-opportunities. As illustrated in the sections above, the outcomes of these discussions did serve to highlight new areas for research, the needs of different stakeholders and contributors in the space, as well as elements of a framework to help advance this important issue. In general, increasing communication between various stakeholders and the characteristics and administration of the training were significant focal points for the discussion. Finally, the outcome of the workshop, this report, is meant to serve not only as a summary of the discussion by the attendees, but also as a resource for stakeholders like those discussed herein to use as a guide for work that results in the development of more inclusive and effective CE approaches.

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