BY THOMAS K. GROSE

GAME ON

Last March, 250 University of Connecticut first-year engineering students gathered virtually for their Foundations of Engineering class, which had moved online during the COVID-19 pandemic. In a break from their usual lecture, however, they were split into groups of four or five and assigned to play a game. Modeled after the popular Cards Against Humanity, in which players respond to a question posed by a prompt card with answer cards that range from ribald to silly, the classroom version probed engineering ethical dilemmas, and one-word responses spanned the comical, obviously wrong, and correct. After 20 minutes, the students regathered in the main forum to discuss the broad issues raised by the game, one of three featured throughout the spring semester.

UConn isn't the only campus dealing up entertaining approaches to teaching engineering ethics. New Jersey's Rowan University also introduced Cards Against Engineering Ethics (CAEE) to a cohort of 109 engineering freshmen. Worcester Polytechnic Institute has experimented with multidisciplinary role-playing activities for first-year students built around an actual 1890s urban sanitation project. And two Cornell University researchers, in a 2019 paper, describe adapting a commercial adventure-style game to introduce ethics to computer science students. Behind the fun and games lies a serious purpose: preparing graduates who can tackle ethically complex technical challenges by providing a safe environment in which to make mistakes and explore the ramifications of decisions.

"Students need to understand the social consequences of their work," explains Scott Streiner, a visiting assistant professor at the University of Pittsburgh's Engineering Education Research Center and CAEE codeveloper, who taught the Rowan freshmen. "Using gaming gets students to think about ethics in different ways."

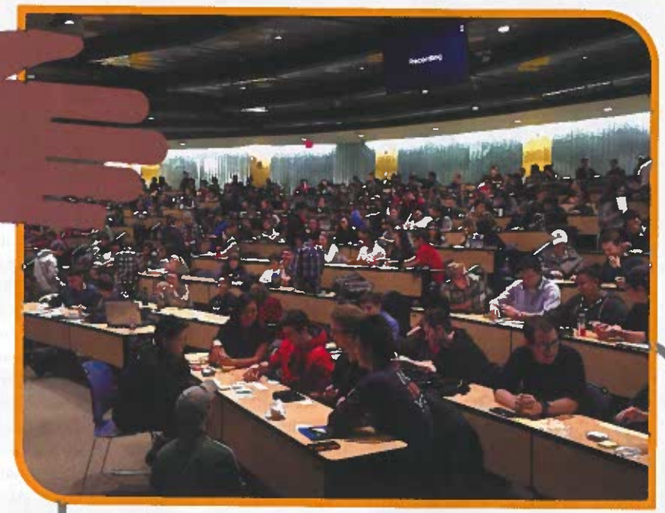
STACKING THE DECK

While professional codes of conduct that stress safeguarding public health and safety date back decades, ethics education is a relatively new component of engineering programs. ABET's precursor, for example, first promulgated ethics guidelines in 1947, but it wasn't until 2000 that the accrediting body's outcomes criteria were revised to require "an understanding of professional and ethical responsibility." How schools instill that understanding can vary widely, from capstone projects to case studies of engineering negligence such as bridge collapses or nuclear power plant disasters. For the most part, however, within the traditional engineering curriculum, ethics training gets short shrift, as merely a philosophical exercise with obvious "right" answers and scant real-world relevance.

Could collaborative game play boost the odds of improving students' ethical reasoning? Streiner and chemical engineer Daniel Burkey, the associate dean for undergraduate education and diversity at UConn's engineering school, are betting on it. They are field-testing Cards Against Engineering Ethics and two other games. Now, just one year into a three-year National Science Foundation-funded study, the two researchers have "encouraging" evidence that playing games can make students more aware of how ubiquitous ethical questions are in the practice of engineering. That's because such simulations immerse students in authentic engineering scenarios in which the correct ethical responses often can vary depending on the situation, and deadlines, bosses, and colleagues can exert pressure to cut corners or look away.

The gamification of some engineering lessons has gained traction in recent years as a way of inspiring deeper reflection and debate. A 2016 *Journal of Engineering Education* systemic review of research on game-based engineering instruction that Burkey coauthored found that the method works to keep students motivated and responsive to content, which can improve learning and attitudes. Using games to teach ethics, however, is rare. Over the past 20 years, only a handful of papers have described ethics-based classroom games, says Burkey, who is "not seeing a whole lot of other people" currently using the strategy. "It's one of the reasons our grant application was successful," he contends. The collaborators are asking, "Can we do this in a game-based way?"

Qin Zhu, an assistant professor of ethics and engineering education at the Colorado School of Mines, is also a fan of ethics-based games. "The gaming approach is quite new," he says, "but it attracts the attention of students, so it engages them more." Zhu's 200-level Global Studies class features a card game called Nano Around the World that was developed at Arizona State University a few years ago. It helps students examine the uneven effects of emerging technologies on rich and poor nations.



University of Connecticut students learn about engineering's ethical dilemmas through engaging card games and a choose-your-own-adventure simulated Mars expedition.

CORE VALUES

Because engineers design, construct, and maintain the products and infrastructure that billions of people rely on, ethics are central to what they do. Engineering ethical failures, whether the 1986 explosion of the space shuttle *Challenger* or the Flint, Michigan, water crisis, inevitably call those values into question. Accordingly, every engineering society has a code of ethics, and ABET's accreditation criteria require in part that students learn to "consider the impact of engineering solutions in global, economic, environmental, and societal contexts." These are minimal standards, however, and Streiner says industry wants schools to play a more active role.

That could involve changing the way ethics is currently taught. Sometimes the subject gets farmed out to the philosophy department. The result, Streiner observes, is that "students see ethics as something separate. But ethics need to be considered and intertwined into everything we do." Case-study modules within engineering design courses enable students to see the disciplinary and professional relevance of ethical decisions. However, the method also makes it easy for them to glom onto the "right" answer, says Burkey. "Our students are astute and can figure out what the correct thing to do is. So it stifles conversation."

By contrast, as Zhu notes, game play is engagement. And engagement leads to learning. "One of the advantages of a game-based education process is it helps students retain knowledge," asserts Burkey. Game playing also compels students to consider less-ethical choices and "removes barriers, so students don't fear being wrong or judged," Streiner explains. "There's no social pressure to be right." Moreover, adds Burkey, "ethical decision-making is often conditional" and based on the situation at hand. Ethics teaching isn't a forum for dictating "The Truth" to students, emphasized a paper that Streiner, Burkey, and coauthors presented about their research at ASEE's 2021 virtual conference. It's about "inviting them to enact their developing 'truths' in the context of the community of engineering practice, with personal reflection and social feedback on their ability to act wisely in various realistic circumstances." Games offer "a tool" to promote conversations about ethics that students might otherwise avoid, concludes Streiner.

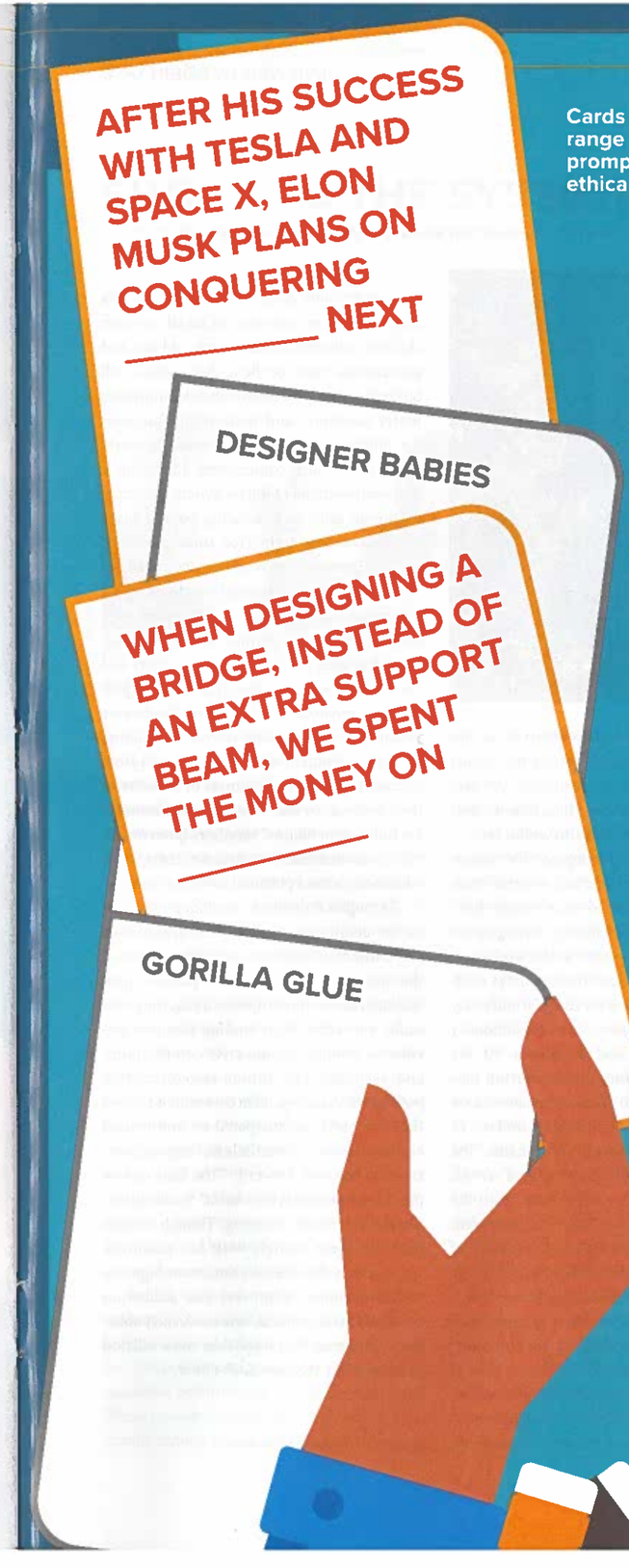
For their study, the team developed three games: Cards Against Engineering Ethics, a scenario-based card game called Toxic Workplaces, and a narrative-based "ethical expedition" to Mars. The first two games were devised to be played in person with actual cards, but the pandemic pushed them online. This spring, students will play face-to-face using their laptops.

CAEE and Toxic Workplaces take around 20 and 75 minutes per session, respectively, and students play them several times during a semester. The Mars adventure is played for a few minutes once a week throughout the semester. "The chances of having an epiphany moment are low" if students play just one short game, Burkey points out, whereas by playing multiple times, "you can move the needle." Before the games commence, students are given some context, usually a short lecture or a case study. Each session is followed by a question-based discussion to get students talking about how they reached their decisions. Though only freshmen have played so far, the games are appropriate for students at any level and could be slotted into any course.

Part of the fun and rationale for CAEE is for students to sometimes choose humorous or unethical responses, which should prompt discussions to help them figure out why those answers are wrong. For instance, when UConn undergraduates first played last spring, one group grappled with a two-part query card: "Volkswagen should have used [blank] to fix their diesel problem instead of [blank]." Team members selected the responses "obviously falsified data" and "poor teamwork and bad communication." That led to a discussion on why faking data is unethical and how poor team dynamics can hamper decision-making.

Toxic Workplaces is based on the TV game show *Family Feud*. Players are presented with an ethical dilemma, then given cards showing several possible answers. They must rank those options from most- to least-picked based on actual survey responses of first-year engineering students from around the country. One scenario involves an engineering company's proposal for a condominium development, which was plagiarized by a lower-bidding rival. The 13 possible responses ranged from taking no action to filing a complaint with the state licensing board. By having students try to figure out how their peers rated the options, the game "generates conversation about the different choices," Burkey says.

Mars: An Ethical Expedition is a choose-your-own-adventure game. It starts with the premise that players are engineers on a Red Planet colony whose communications have been sabotaged. Each week, the students are presented with an ethical dilemma to solve, and their solutions determine how the plot proceeds. The challenges range from life-threatening to mundane, helping students understand that not all choices involve life-and-death issues and preparing them to identify ethical quandaries when they routinely encounter them at work.



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Cards Against Engineering Ethics responses range from the accurate to the hilarious, prompting deep discussions about real-world ethical dilemmas and decisions.

GAME PLAN

All the games, Burkey says, lack right or wrong answers. Students are graded on participation and providing feedback, and they often are asked to write a paper on an issue covered in the game. Their "response has been very receptive," he says. Indeed, surveys of Streiner's Rowan students found that generally all of them preferred games over the usual lectures to learn about ethics. "It introduced a lot of nuance into decision-making and what constitutes an ethical decision," one student commented on his Toxic Workplaces experience. The few negative comments concerned how the games were employed in class, with students asking for more follow-up to help make the connection to ethical choices.

Assessing the effectiveness of game-based ethics instruction has proven as challenging as creating the games themselves. "These things definitely have impact," Burkey says. "The issue is how best to measure the success of something that's intangible." He and Streiner are using a survey tool that quantifies general ethical thinking, the Defining Issues Test, version 2 (DIT2), as well as the Engineering Ethical Reasoning Instrument (EERI), a similar survey that gauges ethical thinking within an engineering context. Students also draw concept maps at the start and end of the semester, which indicate their level of sophistication when considering ethical questions. The idea is to correlate the map with the survey responses. Does a good concept map equate to high survey scores? "If that's true," Burkey says, "then we are on to something."

The researchers also hope to refine their assessment tools and develop new ones, since the standard versions "are not sensitive enough to chart semester changes and are more based on traditional lecture courses," says Streiner. At UConn, a second cohort of students receiving only traditional ethics instruction will provide a point of comparison with their game-taught peers; however, the pandemic introduced additional, conflicting factors—mainly that the researchers haven't had a chance to investigate the games in an in-person class, only in online learning—and they are still analyzing that data. "Nothing definite there yet to report," Burkey says.

Despite his enthusiasm about gamification's potential, Zhu is keen to see if the research shows that this type of instruction helps students retain ethical knowledge and increase their moral sensitivity in the long term. If so, he asks, can those changes lead to better decisions, and "do they have the motivation and courage to act when facing a dilemma?"

Burkey is optimistic about proving the merits of game-based ethics instruction, once his team has finished analyzing the huge amounts of data being collected. "It is encouraging, what we've seen so far," he says. Looks like this inventive approach to teaching ethics could be a game changer.

Thomas K. Grose, Prism's chief correspondent, is based in the United Kingdom.