

Assessing Students' Understanding of Virtues and Ethics through Stories and Case Studies

Olivia Kramer, University of California, Riverside

Olivia Kramer is a fourth year undergraduate Computational Mathematics student minoring in Data Science at the University of California, Riverside.

Meera Vasishta, University of California, Riverside

Meera Vasishta is a fourth year undergraduate Data Science student with a minor in Operations and Supply Chain Management at the University of California, Riverside.

Prof. Hsin-Ling Hsieh, Northern Michigan University

Dr. Hsieh earned her Ph.D. in Economics at UCLA. Her fields of research are Labor and Demographic Economics, International Economics, and Economic Development. She has published research works in various journals. Her 2008 publication in Contemporary Economic Policy analyzed how National Health Insurance in Taiwan raised the probability of retirement among elderly workers lacking an adequate traditional "safety net." Her 2015 coauthored publication in Demography, the flagship journal of the Population Association of America, measured the impact of National Health Insurance on intergenerational living arrangement in Taiwan. Dr. Hsieh is also interested in Cultural Economics. She is currently doing research about the effects of virtue-based education focusing on traditional culture in different countries.

Prof. Dena Plemmons, University of California, Riverside

Dr. Plemmons is the Director of the Research Ethics Education Program at the University of California, Riverside. Her interests are in research on research integrity and curriculum development for integrity and leadership. She has consistently been funded, as PI and Co-PI, through NIH, NSF, and ORI for her research and curriculum development in research ethics, and investigations into common and best practices in areas of scientific practice, both nationally and internationally. She has served as Chair of the Executive Board of the Association for Practical and Professional Ethics, and is the former Editor in Chief of the SpringerNature journal Science and Engineering Ethics. She is an expert consultant to the National Center for Principled Leadership and Research Ethics, and in that capacity works on STEM-focused professional development programs.

Prof. Jiamin Zhang, University of California, Riverside

Jiamin Zhang received her B.S. in Chemical Engineering from Cornell University, and went on to complete her Ph.D. in Chemical Engineering at the University of California Santa Barbara. After completing a postdoc in physics and engineering education at Auburn University, she joined the department of chemical and environmental engineering at the University of California Riverside as an assistant professor of teaching. Her teaching interests include fluid mechanics, soft matter, and engineering design. Her research focuses on developing assessments to measure problem-solving skills of students and incorporating virtue ethics in engineering education. She is also interested in understanding how students learn most effectively.

Assessing Students' Understanding of Virtues and Ethics through Stories and Case Studies

1 INTRODUCTION

Engineering decisions frequently carry significant social, environmental, and human consequences, making ethical judgment a central component of professional engineering practice. As a result, engineering education has increasingly emphasized the importance of preparing students not only with technical competence but also with the ability to recognize ethical issues, evaluate competing values, and justify decisions in morally complex situations.

Current approaches to engineering ethics education commonly rely on a combination of professional codes of ethics and case studies^{1,2}. Codes of ethics, such as the AIChE Code of Ethics³, provide an essential foundation by establishing shared professional norms and expectations. Case studies are frequently used alongside these codes to situate ethical principles within realistic engineering contexts, prompting students to consider trade-offs and consequences. Despite their value, these approaches can lead students to only focus on compliance or outcome-based judgments rather than deeper reflection on moral character and internal motivation.

In recent years, a virtue-based character education approach to engineering ethics has been proposed to address the challenges in current engineering ethics education^{4,5,6,7,8}. Situated in the virtue ethics framework^{4,5,9}, our project aims to use stories from traditional culture as a means to help students identify virtues and articulate how the virtues support an ethical practice of engineering.

Stories have long been used in K-12 and college education. In particular, stories have been used in college education for students to learn about pioneers in STEM¹⁰, practice decision-making¹¹, etc. In our study, we focus on stories from traditional culture of different countries that have an emphasis on virtues and character^{12,13}. Stories from traditional culture contain cultural contexts that are often missing in case studies used for engineering ethics currently. Students with a solid foundation in virtue and engineering ethics can be more engaged in the complex global, social, and ethical dimensions of engineering.

In this manuscript, we will focus on three components of the modules and assessments we developed and implemented in the pilot study of our project in 2024 and 2025. Specifically, we will discuss 1) students' feedback about which stories resonated the most with them, 2) a pre-post assessment we developed as a more quantitative measure of students' improvement in explaining virtues exemplified in a story and connecting the virtues to engineering ethics, and 3) an

engineering ethics case study with added questions to include considerations of virtues. The data can serve as preliminary evidence for the effectiveness of using the stories-based virtue ethics approach and offer resources to other instructors who are interested in implementing similar modules in their courses.

2 METHODS

2.1 Overview

As a pilot intervention, the teaching modules were implemented in the 2-quarter chemical engineering (CHE) capstone design course at a large public university in the Southwest US. The last author is the course instructor. The control group for the study is the environmental engineering (ENVE) capstone design course taught at the same university. The two courses have one hour of shared lecture per week and each course has six hours of tutorial/team consultation per week. In one of the shared lectures, the last author of the paper discussed engineering ethics and introduced students to AIChE code of ethics³. In the section specifically for CHE students, the last author of the paper implemented the teaching modules related to virtue ethics described in this manuscript.

The data included in this manuscript were from the CHE course in 2024 (50 students enrolled, 44 gave consent) and both the CHE course (48 students enrolled, 38 gave consent) and the ENVE course in 2025 (26 students enrolled, all gave consent).

This project was reviewed and approved by the university's Institutional Review Board (IRB protocol number: 30232).

The main teaching modules we developed for this project are Virtue-of-the-Week modules, which are 10-minute short modules at the beginning of the CHE class each week that include the instructor telling a story from traditional culture, asking students which virtues are exemplified, and helping students connect the virtues to engineering ethics. To give students more practice on connecting virtues to engineering ethics, we also developed additional in-class activities and assessments. A more complete overview of the teaching modules is included in our previous publications^{12,13}. For this paper, we will focus on students' feedback on the Virtue-of-the-week modules in the course feedback survey, the pre-post assessment, and the engineering ethics case study activity.

2.2 Feedback Survey

At the end of the course, we administered a feedback survey in the CHE course to evaluate students' perceptions of the teaching modules and to guide improvements of the teaching modules for the following year. Results for some of the survey questions were reported in our previous publication¹³. For this manuscript, we will focus on students' response to the question "Which Virtue-of-the-Week story resonated the most with you?" For each Virtue-of-the-Week module, the story title and a picture related to the story were shown to students in the survey (10 stories in 2024 and 6 stories in 2025). Students were asked to use 1, 2, and 3 to indicate their top three choices, with 1 being the story that resonated the most with them. Students were also asked to write the virtues exemplified in the stories they ranked and briefly explain why the stories

resonated with them. When analyzing the responses, we looked for common themes among the student responses and grouped responses into different themes to capture students' reasons for why the stories resonated with them.

2.3 Development of the Pre-Post Assessment

Previously we have used students' self-reported data as an indirect measure of the effectiveness of the teaching modules. For example, in our previous publication¹³, we noted that 86.0% of students thought the stories from traditional culture helped them better understand virtues and 92.9% of students thought the stories from traditional culture would help them act as an ethical engineer. To more rigorously assess students' improvement in skills that are directly aligned with our research objectives (identifying virtues from stories and connecting virtues to engineering ethics), we developed a pre-post assessment. We used one of the stories that resonated the most with students in 2024 and added more context to the story when writing the pre-post assessment. The assessment centered around the "Han Xin" story, a short narrative describing formative moments from the early life of Han Xin, who later became a prominent general in the founding of the Han dynasty in ancient China^{14,15,16}. Key episodes depict Han Xin enduring poverty, responding to public humiliation with self-restraint, and later repaying kindness and offering forgiveness after attaining power, highlighting virtues such as humility, forbearance, gratitude, and forgiveness. Students were asked to read the story and respond to two open-ended questions. The AIChE Code of Ethics³ was provided to students before Question 2.

Question 1: What virtues can you identify in the story? For each virtue, describe where and how it was exemplified in the story. (Note: A virtue can be defined as a quality considered morally good or desirable in a person.)

Question 2: How do the virtues you identified in Question 1 from Han Xin's story support the ethical practice of engineering? You may connect the virtues to specific parts of the AIChE Code of Ethics³ or discuss the connection to ethical practice more broadly.

In 2025, the pre-assessment was administered at the beginning of the course, and the post-assessment was administered at the end of the course. Students in both the CHE course and the ENVE course were asked to complete the assessment in class and received participation points for completing the assessment.

Student responses to the pre-post assessment were analyzed using a rubric-based qualitative coding approach designed to capture differences in the depth of a student's analysis. The rubric was designed to distinguish between surface-level description and more in-depth analysis of virtues and connections to engineering ethics. The detailed process behind the development of the rubric will be discussed in our future publications. The rubric evaluated responses across three primary dimensions aligned with the assessment questions: identification of virtues from the Han Xin story (Question 1), explanation of virtues (Question 1), and connection of virtues to engineering ethics/code of ethics (Question 2). Each dimension was scored on a scale from 0 to 3. For Question 1, responses were evaluated based on how students identified and explained virtues demonstrated in the story. For Question 2, responses were evaluated based on how effectively students connected the virtues identified in Question 1 to engineering ethics broadly or to specific elements in the AIChE code of ethics. The identification of virtues does not depend on the depth

of student's analysis, only on the number of relevant virtues identified. In this manuscript we will focus on the aspects that depend on the depth of students' analysis: explanation of virtues (Question 1) and connection of virtues to engineering ethics/code of ethics (Question 2).

2.4 Engineering Ethics Case Study

To understand how learning about the virtues affected student's understanding of engineering ethics in the workplace, we reworked a case study previously used by Texas A&M University¹⁷. This case study centered around Goodrich, an engineering company, which was a subcontractor of the company LTV and hired by the Air Force to construct a brake system for the new Air Force light attack aircraft. After repeated test failures, Goodrich engineers submitted falsified qualification reports to the clients, LTV and the Air Force, despite knowing the brake was unsafe. Main characters in the case are a young engineer Lawson who was in charge of testing the brake, his manager Sink, a technical writer Vandivier, his supervisor Gretzinger, and a senior engineer Warren who designed the brake. The case revealed systemic failures in communication, oversight, and engineering ethics, becoming a landmark example of whistleblowing and the moral challenges engineers face when corporate pressure conflicts with public safety.

This case study activity was implemented in the CHE course in 2024 and 2025. Students were first asked to read the case study. We provided students with only the ethical dilemma, not the outcome. This was to encourage students to form their own judgment. Students were then asked to complete a pre-survey to record their own view of the case study. Right after discussing with their group, students were asked to complete a post-survey in class to see if their perspective changed.

In the 2024 implementation, the case study was used similarly to traditional case study methods. In the pre-survey, we asked students what actions Lawson/Sink/Vandivier could have taken and asked them to identify the misconduct/mistakes of people involved in the case study. In the post-survey, we asked students, after discussing with their teammates, whether they would make different decisions if they were Lawson or Vandivier. The only question directly related to virtues in the 2024 implementation was the second question on the post-survey: "what virtues are important for your decision-making?"

In the 2025 implementation, we wanted to incorporate the consideration of virtues throughout the case study activity. We aimed to use this case study as a teaching tool to help students explore engineering ethics through a virtue ethics lens rather than focusing solely on rules or consequences. Specifically, we added two questions prompting students to identify which virtues were demonstrated or lacking before answering what they would do in the same situation. This was to encourage students to think about the virtues before making a decision. Additionally, in the post-survey, after asking if the group discussion changed their responses about what actions they would take, we asked them a reflection question: "what virtues are the most important to you in the work place and why?" We also asked students to provide some feedback about the case study activity: "is there anything missing from the case study that would better help you see the connection to virtues?" Overall, this approach emphasized the role of virtues in ethical decision-making and encouraged students to think critically about the ways in which virtues shape responsible engineering practices.

3 RESULTS

3.1 Feedback Survey

We first added students' ranks for the stories that resonated with them to identify the top two stories that resonated the most with students in each year. In 2024, of the 10 Virtue-of-the-Week modules, the stories that resonated with students were the Mercury and the Woodman story from Aesop's Fables^{13,18} and the Han Xin story^{14,15,16}. The Mercury and the Woodman story was chosen by 24 out of 43 students who completed the feedback survey and gave consent (with 11 first choice, 10 second choice, and 3 third choice) and the Han Xin story was chosen by 21 out of 43 students (with 5 first choice, 6 second choice, and 10 third choice). In 2025, out of 6 stories used (5 Virtue-of-the-Week modules and 1 story in pre-post assessment), the stories that resonated the most with students were also the Han Xin story and the Mercury and the Woodman story. The Han Xin story was chosen by 37 out of 38 students who completed the feedback survey and gave consent (with 22 first choice, 7 second choice, and 8 third choice) and the Mercury and the Woodman story was chosen by 28 out of 38 students (with 3 first choice, 10 second choice, and 15 third choice). In 2025, since the Han Xin story was used in the pre-post assessment, students had more time interacting with the story and the story was also longer than the other Virtue-of-the-Week modules. This may have resulted in more students choosing the Han Xin story in 2025. In 2024, the Han Xin story was used as a Virtue-of-the-Week module and thus had the same format as the other stories.

To provide evidence for validating the approach of using stories from traditional culture and to inform the selection of stories in future years, we are interested in students' specific reasons for why they chose a story as the one that resonated with them instead of the general reasons across all the responses for all stories. So, we focused our analysis on the responses from students that selected the Han Xin story or the Mercury and the Woodman story as one of the stories in their top three choices. For both 2024 and 2025, we looked for common themes among these student responses and grouped responses into different themes to capture students' reasons for why the stories resonated with them. The following are some example quotes from students' responses for the five common themes we identified.

Stories which were chosen by students:

1) exemplified virtues that were the most important to the student or engineers:

"These stories had something I could relate with. They matched a goal or something I held true within my life. Some also provided me with something I strived for or wanted to implement. An example would be Han Xin's behavior in public for the good of the most people."

2) were relevant to daily life or students' experiences:

"Han Xin's story was more meaningful to me because there were some things that my family members experienced at their age that helped me understand many things about this world and how people earn their respect based on their actions."

3) helped students understand consequences of actions:

“Because these stories make me think the opposite of the choices the characters made. I would think the effects of the choices, what happens if the characters chose to do the opposite.”

4) helped students see the value of behaving virtuously:

“For the ‘Mercury and the Woodman’ I think this story resonated with me because it exemplifies the rewards you get when you practice honesty.”

5) helped students recognize the difficulty in carrying out virtues:

“The most important aspect of virtue is actually doing actions that are in line with your morals. The hardest pull away from your morals occurs when a group or society attempts to persuade you to compromise your morals. Each of these stories’ main characters demonstrated the ability to go against the social norms to maintain their virtues and morals.”

The common themes above summarize the reasons why the Han Xin story and the Mercury and the Woodman story resonated with students. When looking more closely at the virtues students identified from these two stories and other stories, we made two additional important observations. First, most students remembered the important virtues in the stories they selected or recollected key episodes from the stories in their responses. Out of all the students who completed the feedback survey and gave consent in the two years combined (81 students), only two students explicitly mention they don’t remember the virtues related to the stories. While some students responded generally about their reasons (e.g., “these stories were the most interesting to me”), the vast majority of the students (59 out of 81, 72.8%) either mentioned the specific virtues or key episodes from the stories. Since the course was 2-quarter long and students completed the feedback survey at the end of the second quarter, the time gap between the Virtue-of-the-Week modules and feedback survey ranged from two weeks to four months. For example, the time gap between when the Mercury and the Woodman story was introduced in class and the feedback survey was nearly four months. Out of 7 hours of class time each week, the Virtue-of-the-Week module only took about 10 minutes of class time. Thus, it was very encouraging to see that students still remembered the stories and the virtues exemplified in the stories.

Additionally, even for the same story, different students had different interpretations of the story or mentioned different aspects of the story that resonated the most with them. For example, for the Han Xin story, different aspects of the story that students highlighted include: “embodies what I value in a leader”, “how he carried himself throughout his life”, “I found it sweet in Han Xin that he made the troublemaker a police commander and gave him a new shot at life”, “showed a story of rags to riches through hard work”, etc.

3.2 Pre-Post Assessment

The pre-post assessment was designed to further validate our approach of using stories to teach students about virtues and help them connect virtues to engineering ethics. We hypothesize that since ENVE students only attend the lecture on engineering ethics but do not participate in the virtue ethics teaching modules, they might show small improvement in scores on the post-assessment compared to the pre-assessment. Since the CHE students participate in both the

lecture and the teaching modules, we hypothesize that they will show larger improvement in scores on the assessment. We are in the process of finalizing the scoring of the pre-post assessment from 2025. The detailed scores of the pre-post assessment is beyond the scope of the current manuscript and will be reported in a future publication after we collect more data with the pre-post assessment in the course this year (2026) as part of our funded research project. Here, we will focus our discussion on the different ways students analyzed the Han Xin story, specifically, the depth of students' analysis of the virtues and how they connected the virtues to engineering ethics.

3.2.1 Question 1: Explanation of Virtues in Practice

Lower-scoring responses (score 1 out of 3) simply summarized events from the narrative or described specific actions without explicitly identifying virtues. Mid-level responses (score 2 out of 3) explicitly named one or more virtues and provided thorough explanations supported by specific examples from the story. Higher-scoring responses (score 3 out of 3) demonstrated more advanced reasoning by moving beyond descriptive explanation to 1) offer an interpretation of the underlying reasons behind the character's actions, 2) extend the analysis beyond the immediate context of the story, 3) or discuss alternative courses of action for two or more virtues. A few students had truly exceptional responses, demonstrating two or more criteria listed above, so we noted their scores as 3+.

Here are a few excerpts of representative responses from students who got a score of 3 or 3+:

“Virtue of forgiveness: ...When he came across the man that had made fun of him, he did not look at him with a lens of disdain but rather a neutral standpoint, arguably in a favorable light. Han decided to bring the man to a position of power himself in spite of his past actions, showing that Han recognized potential good in the man that could be supported. It's not stated directly, but it can be assumed that Han holds to the belief that at times good people can be going through a troubled time that may not put them in the best light and may even lead to bad decisions but it is not representative of who they are as a whole. People can be given a second chance to prove themselves if they show true intention and effort.”

“Virtue of strength, humility, and morality: ...True strength is choosing not to fight even when you are able to and avoiding the path with the most violence/conflict even when presented an opportunity to like it was here. I believe this mindset is also important and successful in military and violent conflict as well which could have been why he became a distinguished general...”

“...Loyalty/Trust - It would have been easy for Han Xin to forget about the woman who fed him as it had been a long time and he was now in a position of power. Instead, he returned to his own town and repaid her with more than she could have imagined and lived up to his promise...”

3.2.2 Question 2: Connection of Virtues to Engineering Ethics

Lower-scoring responses (score 1 out of 3) referenced engineering ethics or the AIChE Code of Ethics only superficially, offered limited explanation, or failed to clearly connect virtues or story scenarios to ethical engineering practice. Mid-level responses (score 2 out of 3) demonstrated clearer connections by linking virtues or scenarios to one or more elements of the code and explaining what those elements mean for engineering practice, even without detailed examples. Higher-scoring responses (score 3 out of 3) showed more sophisticated integration of virtue ethics and professional standards by either 1) providing thorough explanations connecting virtues to a specific element of the code with concrete examples or 2) by connecting virtues to multiple elements of the code while clearly articulating the professional significance of each connection.

Here are a few excerpts of representative responses from students who got a score of 3:

“[Element of Code of Ethics ‘formally advise their employers or clients if they perceive that a consequence of their duties will adversely affect the present or future health or safety of their colleagues or the public’] can be encompassed in the virtue pertaining to treating others as you would like to be treated. If I as a professional engineer found an issue in the performance of my product/design then the client/etc. should be assured that any of this would be appropriately addressed so as to prevent any issues in regards to product safety to the public/employer/etc. This same concept would apply if I took my car to the local mechanic and asked them to do an oil change then to check on the car to see if anything else needs to be worked on with the engine. If they service my car and come back to let me know that while working they noticed that there’s an uneven wear and hazardous deterioration on a tire, even though I only specified the engine and oil change, it would be my hope that they would let me know of the issue and how dangerous of a risk it poses.”

“Hard work can be depicted with [the code element ‘continue their professional development throughout their careers, and provide opportunities for the professional development of those under their supervision.’] The code calls engineers to continue their development in order to help future engineers succeed and to make the world a better place. It would be easy to become complacent but just how Han Xin kept working to become the top general in the army, it is an engineer’s duty to keep developing and pursuing new learning to become better as engineers are always dealing with the public’s safety and wellbeing.”

3.3 Engineering Ethics Case Study

Student responses from the 2024 and 2025 implementations of the case study demonstrate that framing the Goodrich brake failure case study through a virtue ethics lens helped students meaningfully identify ethical strengths and failures in engineering practices. Students analyzed ethical decision-making through the lens of virtue ethics, focusing on how individual character traits influenced actions and outcomes. Using the answers to questions given in the 2025 pre-survey, specifically the questions about what virtues were lacking and what virtues were demonstrated in the case study, we developed a character-virtue-situation mapping. This mapping

connected characters mentioned in the responses, the virtues that were associated with them, and the relevant situation that either demonstrated or failed to demonstrate the virtue.

To create this mapping, we took student responses and parsed the necessary information out of each response. For example, one student wrote “Vandivier showed honesty about the design and did the right thing in letting the boss know about the results” in response to what virtues were being demonstrated in the case study. The character-virtue-situation being presented in this particular response would be Vandivier-honesty-report to supervisor. Using R-Studio, we created an alluvial diagram depicting this mapping, for both the virtues demonstrated and the virtues lacking. Figure 1 represents the mapping for the virtues demonstrated. The left column is the list of main characters students mentioned, the middle column is the list of virtues, and the right column is a short summary of the relevant situation. Each virtue is represented by a different color in the diagram. The bands connecting two columns represent the connection between them and the thickness of the band represents the number of times the connection is mentioned in student responses. The responses that share the same connection among all three columns, character-virtue-situation, are grouped in the same band.

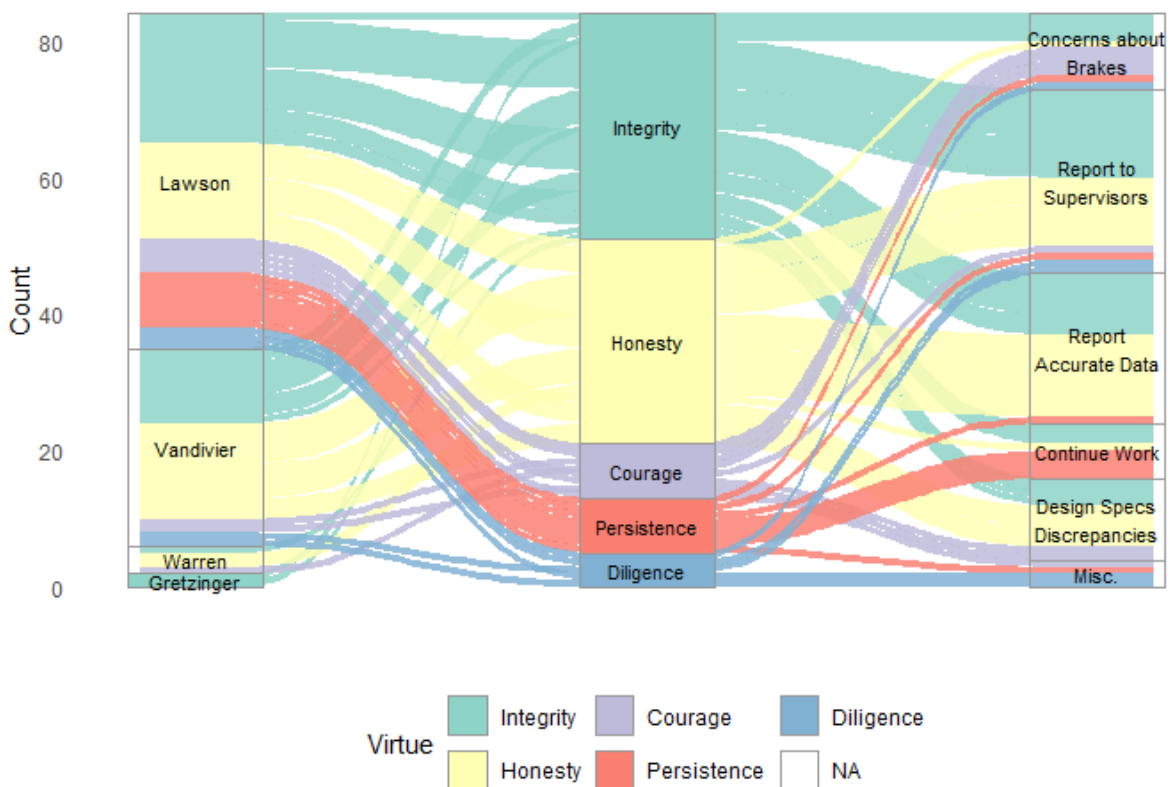


Figure 1: Alluvial diagram for virtues demonstrated by main characters in different situations in the engineering ethics case study.

The alluvial diagram shows how students are able to identify situations in the case study that demonstrate relevant virtues. When analyzing the actions of Lawson and Vandivier, students most frequently identified honesty, integrity, and courage as the key virtues demonstrated. These

virtues were strongly associated with decisions involving reporting to supervisors, challenging unsafe designs, and ensuring accurate reporting of data. This alluvial diagram illustrates that Lawson and Vandivier demonstrated integrity and honesty, which resulted in actions such as reporting design concerns and exposing data discrepancies.

In contrast, students overwhelmingly associated Goodrich leadership figures, particularly Warren, Sink, and Gretzinger, with a lack of virtues (e.g., integrity, accountability, teamwork, and responsibility). These deficiencies were most commonly connected to decisions involving ignoring known design flaws, misleading clients, falsifying data, and failing to follow through on safety concerns.

The questions about the virtues demonstrated and virtues lacking were only given in the 2025 pre-survey. Across both years, students were asked similar questions concerning what virtues were important (specifically, the question in 2024 was about virtues important for their decision-making about the case study, the question in 2025 was about virtues important to students in the work place). Honesty and integrity were the most frequently seen responses from both 2024 and 2025. To explain why these virtues were important, many students focused on safety and quality of work as the dominant ethical concerns in the field of engineering. These themes were echoed in both the 2024 and 2025 surveys, indicating similarity in how students interpreted ethical responsibility when guided by virtue-based reflection.

The addition of a virtue-identification prompt in the 2025 pre-survey appeared to strengthen students' ability to articulate ethical reasoning before proposing actions. Rather than focusing solely on what should be done, students demonstrated greater awareness of why certain actions were ethical, grounding their decisions in virtues. This aligns with our overall goal of the intervention, encouraging students to view ethical engineering practice as rooted in virtue and personal responsibility rather than compliance alone.

4 DISCUSSION

The results from our first two years of piloting the teaching modules were quite encouraging. Overall, we found that students felt the stories from traditional culture resonated with them and students demonstrated their abilities to identify virtues from stories and connect the virtues to the ethical practice of engineering. Here, we'd like to offer our perspectives on why stories from traditional culture are useful for the teaching of engineering ethics.

In 2024 and 2025, when we asked students in the feedback survey at the end of the course, we found that a vast majority of students were able to remember the virtues and key episodes from the stories. This was quite encouraging. As instructors of college courses, we often find that students don't remember key information after a few weeks, especially if the exposure in class is quite short. Here, it seemed the stories made a lasting impression on students. Even after two to four months, students had a good recollection of the stories.

Additionally, stories from traditional culture allow students to have their own interpretations and different aspects of the story resonate with different students. Students are invited to bring their whole self to the engineering practice when stories are introduced in the classroom. As we observed in the feedback survey, a number of students mentioned the stories were related to their

life experiences. We hypothesize that this story-based approach to engineering ethics can possibly make engineering more appealing to students. This can be especially useful when implemented in first year engineering courses to encourage students to pursue engineering majors. Additional studies need to be conducted in order to validate this hypothesis.

On the contrary, it might be harder for students to remember and resonate with engineering ethics case studies. Previous studies have shown a lack of student interest in common approaches of engineering ethics education (using case studies and codes of ethics)⁶. One of the reasons for this is we don't expect undergraduate engineering students to have much experience with engineering practice. With limited experience in the engineering industry, students may not be able to bring their own experiences when analyzing engineering case studies.

Thus, stories from traditional culture and engineering case studies are complementary. When used together, they can make the teaching of engineering ethics more effective and more resonating for students.

Another main point we wanted to discuss is the need for developing assessments aligned with our research objectives. From our literature search, we found validated assessments for engineering ethics, such as the Engineering and Science Issues Test (ESIT)¹⁹, Engineering Ethical Reasoning Instrument (EERI)²⁰, and Engineering Professional Responsibility Assessment (ERPA)²¹. Additionally, there are validated assessments for virtues, such as Values in Action Inventory of Strengths (VIA-IS)²² and Virtue-Based Self-Assessments²³. However, to our knowledge, there aren't any validated assessments that connect virtues to engineering ethics. Therefore, to specifically assess the educational objectives associated with our project (identifying virtues from stories and connecting to engineering ethics), we started developing our own pre-post assessment. As we collect more data, we will continue to develop and refine the pre-post assessment. We hope the pre-post assessment can be useful for other instructors as well.

5 LIMITATIONS AND FUTURE WORK

With only 44 CHE students in 2024, 38 CHE students and 26 ENVE students in 2025, our sample size was quite small. Although having two years of data helped increase the sample size, the scope of the project was limited to one university and one type of course (CHE capstone design) for the experimental group. Additionally, the main researcher for the project is the instructor of the course. In order to further validate our approach, we plan to collaborate with other instructors to implement the virtue ethics teaching modules in courses from different engineering majors and course levels (e.g., first year chemical engineering course, senior year computer science course).

Within the current CHE capstone design course, having had two years of successful pilot interventions, we plan to start the full project this year (2026). The focus of this year is phase 1 of the project, which is using stories from traditional culture to help students identify virtues and make connections with engineering ethics. To improve the quality of data we collect, we will continue to refine assessment and survey questions. We will also finish analyzing the pre-post assessment from 2025 to more quantitatively compare the results between the experimental group and the control group.

For next year (2027), the focus will be on phase 2 of the project, which will have a bigger emphasis on ethical decision-making. To accomplish this goal, we will start to develop virtue-of-the-day modules that use stories with decision-points embedded to allow students to practice making the decisions before hearing what the main characters in the stories decided to do. Additionally, we plan to modify more engineering ethics case studies to include consideration of virtues.

6 ACKNOWLEDGMENTS

We would like to thank Dr. Michael Loui and Dr. Linda Zagzebski for helpful discussions and thank Dr. Amanda Rupiper for coordinating data collection in the environmental engineering senior design course. This project was supported by grants from the US National Science Foundation (EEC-2508905) and the UC Hellman Fellowship.

References

- [1] C. for Engineering Ethics and I. E. S. Committee, *Infusing ethics into the development of engineers: Exemplary education activities and programs*. National Academies Press, 2016.
- [2] J. L. Hess and G. Fore, “A systematic literature review of US engineering ethics interventions,” *Science and engineering ethics*, vol. 24, pp. 551–583, 2018.
- [3] AIChE. (2015) AIChE code of ethics. [Online]. Available: <https://www.aiche.org/about/governance/policies/code-ethics>
- [4] C. E. Harris, “The good engineer: Giving virtue its due in engineering ethics,” *Science and Engineering Ethics*, vol. 14, pp. 153–164, 2008.
- [5] H. Han, “Virtue ethics, positive psychology, and a new model of science and engineering ethics education,” *Science and engineering ethics*, vol. 21, no. 2, pp. 441–460, 2015.
- [6] O. Pierrakos, M. Prentice, C. Silverglate, M. Lamb, A. Demaske, and R. Smout, “Reimagining engineering ethics: From ethics education to character education,” in *2019 IEEE Frontiers in Education Conference (FIE)*. IEEE, 2019, pp. 1–9.
- [7] J. Koehler, O. Pierrakos, and A. Yeaman, “Character development in the engineering classroom: An exploratory, mixed-methods investigation of student perspectives on cultivating character,” in *2023 ASEE Annual Conference & Exposition*, 2023.
- [8] K. McDonald, “Character-based engineering virtues,” in *2023 ASEE Annual Conference & Exposition*, 2023.
- [9] L. Zagzebski, *Exemplarist moral theory*. Oxford University Press, 2017.
- [10] S. Collins, T. Steele, and M. Nelson, “Storytelling as pedagogy: The power of chemistry stories as a tool for classroom engagement,” *Journal of Chemical Education*, vol. 100, no. 7, pp. 2664–2672, 2023.
- [11] J. Hayes and S. Maslen, “Knowing stories that matter: learning for effective safety decision-making,” *Journal of Risk Research*, vol. 18, no. 6, pp. 714–726, 2015.
- [12] J. Zhang, N. Gutlapalli, O. Truong, B. Sutjipto, H.-L. Hsieh, and D. Plemmons, “WIP: Using stories from

- traditional culture to teach virtue-based engineering ethics,” in *2024 IEEE Frontiers in Education Conference (FIE)*. IEEE, 2024, pp. 1–5.
- [13] J. Zhang, Q. T. O. Truong, N. Gutlapalli, H.-L. HSIEH, and D. Plemmons, “Developing stories from traditional culture into case studies for teaching virtue ethics in engineering,” in *2025 ASEE Annual Conference & Exposition*, 2025.
 - [14] Q. Sima, *Records of the Grand Historian*, 91 BC.
 - [15] Shen Yun Performing Arts. (2020) Ren: to be patient, to endure. [Online]. Available: <https://www.shenyun.org/explore/view/article/e/hfseQOYDpsA/ren-endure-tolerance-forbearance-fun-with-chinese-characters.html>
 - [16] Vision Times. (2021) In China, giving thanks is to repay kindness. [Online]. Available: <https://www.visiontimes.com/2021/11/22/chinese-culture-and-giving-thanks.html>
 - [17] Texas A&M Civil Engineering Ethics Site. (2017) B.F. Goodrich air force A7-D brake problem case and the whistleblowing debate. [Online]. Available: <https://ethics.tamu.edu/wp-content/uploads/sites/7/2017/04/Goodrich.pdf>
 - [18] Aesop, “Mercury and the woodman,” in *Aesop’s Fables*. [Online]. Available: <https://read.gov/aesop/102.html>
 - [19] J. Borenstein, M. J. Drake, R. Kirkman, and J. L. Swann, “The engineering and science issues test (ESIT): A discipline-specific approach to assessing moral judgment,” *Science and Engineering Ethics*, vol. 16, no. 2, pp. 387–407, 2010.
 - [20] Q. Zhu, C. B. Zoltowski, M. K. Feister, P. M. Buzzanell, W. C. Oakes, and A. D. Mead, “The development of an instrument for assessing individual ethical decisionmaking in project-based design teams: Integrating quantitative and qualitative methods,” in *2014 ASEE annual conference & exposition*, 2014, pp. 24–1197.
 - [21] N. E. Canney and A. R. Bielefeldt, “Validity and reliability evidence of the engineering professional responsibility assessment tool,” *Journal of engineering education*, vol. 105, no. 3, pp. 452–477, 2016.
 - [22] C. Peterson and M. E. Seligman, *Character strengths and virtues: A handbook and classification*. Oxford university press, 2004, vol. 1.
 - [23] J. Baehr, *Deep in thought: A practical guide to teaching for intellectual virtues*. Harvard Education Press, 2022.