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Authentic process safety decisions in an engineering ethics context: expression of student moral development within surveys and immersive environments

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ABSTRACT

Two methods of assessing senior chemical engineering student ethical decision making in a process safety context were developed; the case-study-based Engineering Process Safety Reasoning Instrument (EPSRI) and a digital immersive environment entitled *Contents Under Pressure*. Both interventions had similar ethical and process safety decision prompts, but were presented in different manners; the EPSRI as a traditional electronic survey, and *Contents Under Pressure* as a digital immersive environment ('game'). 148 chemical engineering seniors at three institutions responded to both interventions and responses were compared. Student responses to the traditionally formatted EPSRI revealed most students applied post-conventional reasoning, which is uncommon for students in their age range. This suggests that students are aware of the ethical framing of the instrument, and answer accordingly with the perceived 'right' response. Student responses to *Contents Under Pressure* showed significant differences from the EPSRI, including more typical conventional responses. These results suggest that the authenticity of the digital environment can produce more realistic student responses to ethical and process safety dilemmas. Situating ethical and process safety instruction within this type of educational intervention may allow students to gain insight on their ethical decision making process in a safer, low-risk environment.

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Educational software; ethics; chemical engineering

1. Introduction and background

A key component of engineering practice is the ethical responsibility towards the safety, health, and welfare of the public. This ethical responsibility is codified in the Codes of Ethics for many engineering societies (National Society of Professional Engineers 2020; American Institute of Chemical Engineers 2020; American Society of Mechanical Engineers 2020). Safety has been found to be the topic most often mentioned by engineering faculty who teach ethics courses, with one faculty member stating, 'safety is 50 to 60% of ethics (Colby and Sullivan 2008), p. 330.' This viewpoint is supported by the 2011 decision by the Accreditation Board for Engineering and Technology (ABET) requiring process safety instruction be included as part of the curriculum of chemical engineering programmes (ABET 2020).

Unfortunately, teaching process safety in an effective manner is difficult in an engineering classroom setting. Common strategies involve reviewing case studies of process safety incidents and/or completing engineering tasks associated with process safety incident prevention (Jonassen et al. 2009; Dixon and Kohlbrand 2015). Though these strategies expose students to process safety and the ramifications of a lack

thereof, they do not have the robustness to train students in process safety in a general fashion. For example, an assignment requiring students to properly size a relief vent after viewing a case study where an incorrectly sized relief vent resulted in a safety incident only teaches one measure towards improving process safety. The benefit of hindsight when reflecting on this incident also leads to damaging confirmation bias (Colby and Sullivan 2008).

Preventative measures are not the only way in which engineers affect engineering safety; rather, many process safety incidents result from poor ethical decision making by the individuals involved with the situation (T2 Laboratories Inc. Reactive Chemical Explosion; Blocked In: Explosion and Fire at Williams Olefins Plant, Geismar, Louisiana; MGPI Processing, Inc. Toxic Chemical Release). An example of the impact of ethical decision making in engineering process safety is the 2013 explosion and fire at the U.S. petrochemical facility Williams Olefin (Blocked In). In this incident, a change in process configuration was carried out without the typically required Management of Change documentation; this documentation would have taken time and resources to complete, and so was ignored. When the new process

was brought back on-line, the improperly-vetted new configuration resulted in an explosion that killed two and injured 167 others. This accident clearly demonstrates the close connection between ethical decision making (the decision not to follow proper procedure and documentation requirements, based on a perception of low risk) and process safety outcomes (improper system configuration and explosion).

A common avenue towards evaluating ethical decision making is using a written situation-based instrument to place individuals into ethical dilemmas that require immediate decisions. The classic exemplar of this approach is the DIT and DIT-2 tests (Rest et al. 1974; King and Mayhew 2002). In these instruments, participants are confronted with a series of moral or ethical dilemmas, and are asked to make a decision on how to proceed. These DIT instruments are framed using Kohlberg's moral development theory (Kohlberg 1981, 1985), which maps the structure and mechanics of decision making using to an individual's moral reasoning level. These three levels are pre-conventional, conventional, and post-conventional where each level acts as a category of motivating factors. Pre-conventional reasoning is the concern for one's own best interests, particularly time and money invested in that decision. Individuals often use pre-conventional reasoning early in childhood; for instance, a child using pre-conventional reasoning may take candy or food from a younger sibling without regard for the sibling's welfare. Conventional reasoning is the concern for the wellbeing of those immediately around you such as family members, friends, and co-workers. Socialisation is typically responsible for an individual gaining conventional reasoning; the desire to be accepted by one's family and peers drives this transition. Post-conventional reasoning is the concern for the greater good such as human rights, or the wellbeing of a community or the environment. Mapping out levels of moral reasoning allows for discussion on how decisions were made without judging whether the decision was ethically correct (Kohlberg 1981, 1985). The relationship among the levels of moral reasoning can be described as three inscribed circles as shown in Figure 1. As discussed, at a young age individuals begin making decisions with a pre-conventional level of moral reasoning and are constricted to the circle shown in Figure 1. As individuals advance to higher, external layers of moral reasoning, the lower levels are still encompassed showing that these motivations still exist. This development is an additive, non-discrete process that occurs from education and gaining life experience. Within each level of moral reasoning, two schemas exist which show if an individual is consolidated or transitional within that level. 'Role' and 'events' play a part in moral reasoning as they are associated with experience, which is why the context

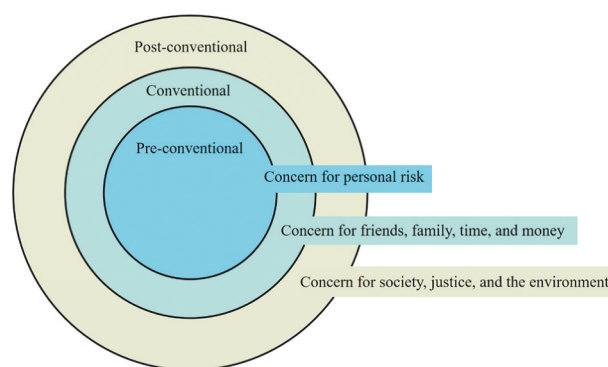


Figure 1. Model of moral reasoning levels.

of situation-based instruments needs to be taken into consideration when used (Rest et al. 1999).

Unfortunately, the nature of written surveys such as the DIT-2 may affect the accuracy with which it is possible to assess ethical decision making. Participants may realise they are engaging in an 'ethics' exercise, and thus choose to make the most ethical or 'correct' choice. This approach can be contrasted against the aforementioned Williams Olefin incident. At many points leading up to the explosion it was clear the 'right' thing was to complete the MOC before making a configuration change, but the engineering personnel operating the process still decided against it. This realisation highlights a key issue with decision making training, namely the difference between ethics (what people should do) and behavioural ethics (what people actually do). This difference in ethical decision making is examined in detail by Bazerman and Tenbrunsel in their text *Blind Spots: Why We Fail to Do What's Right and What to Do about It* (Bazerman and Tenbrunsel 2011). Bazerman and Tenbrunsel's backgrounds are both as educators and researchers in ethics. From this background, they wrote *Blind Spots* as a compilation of books, historical events, and journal studies covering topics from psychology to business ethics to engineering failures in order to demonstrate the complexity of failures within ethical decision making. Bazerman and Tenbrunsel argue that ethics training fails, and will continue to fail, because the training is designed with the false assumption that people, when placed in a dilemma, will be able to identify that their decision has an ethical component. In the case of the Williams Olefins disaster, it is possible that engineers were motivated by time or financial constraints to make the configuration change quickly, 'fading' their ethical responsibility to safety when making these decisions. Bazerman and Tenbrunsel further argue that if decision making training is to succeed, 'it needs to incorporate behavioral ethics and the subtle ways that ethics are bounded (Bazerman and Tenbrunsel 2011), p. 5'. For instance, in addition to time and financial pressures, many psychological tests have shown that people will

knowingly engage in unethical behaviour to fulfill their obligations to authority (Milgram 1963; Burger 2009). This authority figure could take many roles, such as enabling an individual to perform unethical acts if the individual in question were instead focused on pleasing their supervisor or management. Without these incentives and disincentives, it is difficult to accurately assess a person's ethical decision-making ability.

Written instruments such as the DIT-2 also suffer because people are often not very good at judging their own ethical decisions. It has been observed that people will often predict they will make the ethical choice but later make an unethical choice because they do not recognise a decision's ethical components in the moment. Upon later reflection on that unethical decision, individuals will often justify themselves as having been ethical since they predicted they would always act ethically (Tenbrunsel et al. 2010). In the case of the DIT-2, participants are necessarily predicting how they will behave in the future, when humans have been shown to be susceptible to behavioural forecasting errors (Osberg and Shrauger 1986). With this behaviour in mind, an evaluation strategy based on preauthentication may be more effective for decision making.

Preauthentication can be described as the use of an immersive 'practice field' where participants are placed in an authentic setting, then asked to make decisions in the context of this setting as though they actually exist there (Nicaise, Gibney, and Crane 2000; Radinsky et al. 2001). This preauthentication strategy has been identified by the engineering ethics literature to be effective in decision making education (Manenti 2012; Shepherd 1986). The preauthentication setting allows participants to experience simulated pressures and accountabilities in the setting while also being exposed to decisions involving factors such as cost, time, and other personal and public concerns (Colby and Sullivan 2008). Active engagement in the preauthentication arena has been found in some cases to be more effective than interacting in a more passive environment (Bransford, Brown, and Cocking 1999; Pascarella and Terenzini 2005) and exposes participants' understanding of the complex issues surrounding ethical decisions more effectively than a written evaluation (Colby and Sullivan 2008). Unfortunately, preauthentication is difficult to achieve in the engineering field, where consequences of poor decision making could prove dangerous (Patle, Ahmad, and Rangaiah 2014; Manenti 2012).

In order to investigate the differences between ethical assessment methods in the context of engineering process safety, both a written survey-based safety decision instrument (EPSRI) and *Contents Under Pressure*, a digital immersive environment ('game') have been developed. This work seeks to answer the research

question 'What differences exist between students' expressed moral reasoning when taking surveys and when interacting with a more immersive digital environment?'

2. Methods

To examine if any differences exist between students' expressed moral reasoning in the two contexts provided, both the EPSRI and *Contents Under Pressure* were given to students. This section provides an overview of both contexts within which students' process safety decision making was measured as well as the data analysis that was conducted to answer the proposed research question.

2.1. Engineering process safety research instrument (EPSRI)

The EPSRI was developed based on the ethical reasoning instrument DIT-2 (Rest et al. 1974, 1999; Rest, Edwards, and Thoma 1997; Rest et al. 1997; Rest, Bebeau, and Thoma 1999) as well as related instruments such as the Engineering Ethical Reasoning Instrument (EERI) (Zhu et al. 2014) and Engineering and Science Issues Test (ESIT) (Borenstein et al. 2010), but differs due to its process safety focus (Bodnar et al. 2020; Butler et al. 2019; Anastasio et al. 2019; Butler et al. 2018). The instrument has five ethical dilemmas, each involving a decision prompt, and ten to twelve considerations for reflection. Dilemmas were developed based on process safety incidents reported by the Chemical Safety Board (CSB) and personal experiences of the researchers (Butler et al. 2018). Decision options available within the EPSRI include two opposing actions that may be taken to resolve the dilemma as well as a 'Can't Decide' option. Once a choice is made, each of the reflection considerations are rated with a Likert scale rating ranging from 1, meaning the consideration had 'No' impact on the proposed decision making process, to 5, representing 'Great' impact on the decision making process. Each consideration mapped to one of the three levels of moral reasoning, and the number of considerations per moral reasoning level varies from three to four depending on the dilemma. A nonsense consideration is also included to assist with reliability assessment of student responses. The EPSRI has been content validated by field professionals and experienced educators (Butler et al. 2018). The survey duration varies by student but averages 45 minutes.

The results from the second dilemma of the EPSRI were solely used in this analysis, rather than the results from all five dilemmas in the instrument, because this scenario most closely reflected the narrative arc within *Contents Under Pressure* thereby providing the best direct comparison between the two process safety

decision making contexts. A summary of the dilemma as taken from page 6 of (Stransky et al. 2020) follows

The second dilemma in the EPSRI places the students into the position of a plant engineer at a chemical company in the suburbs of a major city. There's a severe hurricane heading towards the plant, and if the plant floods, there is the possibility of extreme hazardous events such as an explosion. It is possible that the storm is not as severe as predicted and that the plant will not fail, but the student is asked to make the decision. Should they solicit volunteers to help the plant weather the storm, or should they rely solely on the plant's construction and hope it holds out. Students could also choose the Can't Decide option.

In this dilemma, individuals are asked to balance between whether it is best to potentially put their employees at risk by having them stay to help assist with any issues that might occur at the plant during the hurricane or to send them home to be with their families with the knowledge that this could lead to potential operational issues that may impact the local community and environment. Example considerations for this dilemma are shown in Table 1.

2.2. Contents under pressure

Contents Under Pressure is a digital immersive environment (game), which was developed in collaboration with Filament Games. The goal of using a game is to provide students with a more authentic training experience in process safety decision making than may be accomplished in a classroom based setting (Raza et al. 2019). Similar to pilot training on flight simulators, engineers can use games to train in scenarios that are often high-risk where mistakes are costly and dangerous. As an analogy, aviation pilots have used transferable experience from flight simulators for decades to train for reaction time and cognitive load (Gopher, Weil, and Bareket 1994). An engineering simulator may be similar in building experience and training for cognitive load, but it would differ in

time for reward or consequence of decisions made in the simulation.

The game consists of a fifteen-day narrative based on the EPSRI's second dilemma and the events of Hurricane Harvey on chemical facility operation as reported by the CSB (Organic Peroxide Decomposition, Release, and Fire at Arkema Crosby Following Hurricane Harvey Flooding 2017). A single day of the narrative arc in *Contents Under Pressure* takes on average five to ten minutes for a student to complete. In an effort to increase the amount of interaction that students have with *Contents Under Pressure*, the digital immersive environment restricts students from playing more than a single day of the narrative per calendar day. During immersion, students' role play as a senior plant engineer and interact with virtual characters by responding to their concerns, requests, and demands. Characters with which students interact include three subordinate employees, a plant manager, a safety supervisor, and their own adopted daughter. Students must balance realistic industry metrics (i.e. time remaining in the workday, plant safety, their character's reputation, and plant productivity) which are affected by the decisions made during interactions with characters. A screenshot of the interface is shown in Figure 2.

In addition to prompts given by the characters, reflection prompts occasionally appear within the game to assess how students' decision making was impacted by information tied to different levels of moral reasoning. The appearance of a reflection prompt is shown in Figure 3. Within the reflection prompts, students are asked to rate the impact the provided information had on their decision-making process using a Likert scale ranging from 1 (representing Very Irrelevant) to 5 (representing Very Relevant). Example reflection prompts are shown in Table 2 for each moral reasoning level.

Table 1. Example considerations within Dilemma 2 of the EPSRI based on moral reasoning level.

Moral Reasoning Level	Example Consideration	Number of Considerations in Dilemma 2
Pre-Conventional	Keeping your unit running during a storm sometimes requires personal sacrifice. How relevant is this to your decision?	4
Conventional	Employees can get hurt operating unfamiliar equipment. How relevant is this to your decision?	4
Post-Conventional	With no one around, the plant could have serious issues that impact the surrounding communities. How relevant is this to your decision?	4

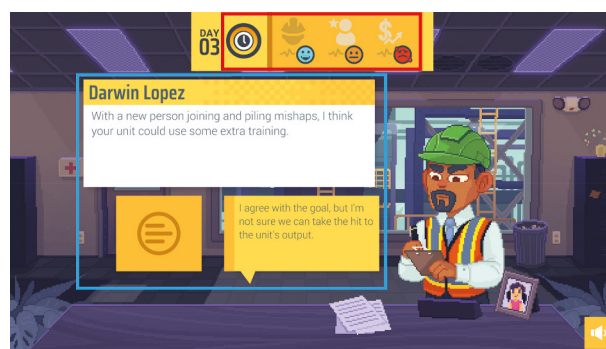


Figure 2. Screenshot of *Contents Under Pressure* interface. The metrics students balance are boxed in red where the clock represents time remaining in the work day, the construction hat represents plant safety, the person with a star represents personal reputation and the dollar sign represents plant productivity. Students can see the levels of these metrics by checking the associated icon, where a blue smiling face represents a high level and a red frowning face represents a low level. The card prompt and decision options are boxed in blue.

2.3. Study design

The EPSRI and *Contents Under Pressure* were implemented during the Fall 2019 term at three ABET accredited institutions to senior chemical engineering students enrolled in a senior design, process safety, or professional practice class. The EPSRI was administered to students at the start of the term as either an in-class or a homework assignment. Then, *Contents Under Pressure* was administered as a homework assignment over the span of three weeks. Students' decisions and consideration ratings for the EPSRI and reflection prompt selections for *Contents Under Pressure* were recorded using the identification codes for a paired analysis. 224 responses were recorded for the EPSRI, and 186 responses were recorded for *Contents Under Pressure*. Using anonymous, unique user identification codes, responses were reduced from both samples to create a final paired sample population of 148 senior chemical engineering students. Proper human subjects' approval was obtained prior to data collection and analysis.

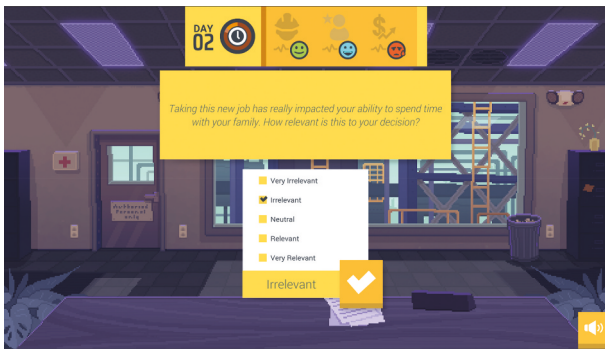


Figure 3. Screenshot of a reflection prompt from *Contents Under Pressure* interface.

Table 2. Example considerations within *Contents Under Pressure* based on moral reasoning level.

Moral Reasoning Level	Example Consideration	Number of Reflection Prompts in <i>Contents Under Pressure</i>
Pre-Conventional	What is your level of concern regarding your own personal safety if you choose to stay onsite during the storm?	13
Conventional	Are you concerned your co-workers could be injured or killed if they stay at the plant during the hurricane?	35
Post-Conventional	Is there the potential for the exploding tanks to damage the surrounding neighbourhood and infrastructure adjacent to the plant?	14

2.4. Data analysis

Student consideration ratings for the EPSRI or reflection prompt ratings for *Contents Under Pressure* within a designated moral reasoning level were averaged. These values were then compared both within their native context (i.e. EPSRI or *Contents Under Pressure*) and then across contexts using a paired t-test. As multiple considerations were performed when doing the single context comparison, the produced p-value of this test was adjusted using a Bonferroni correction since multiple tests may lead to an increased probability of false positives (Bland and Altman 1995; Perneger 1998). In addition to the paired t-test, the effect size was calculated between pairs using Cohen's *d*. Effect size is necessary to consider in a statistical analysis to observe the magnitude of difference between populations (Sullivan and Feinn 2012). In studies with large populations, comparisons may be reported as significant, so effect size, which is not dependent on the size of the population, supplements this value.

In cases where a specific consideration on the EPSRI was quite similar to a reflection prompt provided within *Contents Under Pressure*, additional analysis was performed to determine whether students had specifically responded differently to the statement based on the context within which they were exposed to it. This additional analysis helps address the discrepancy in the number of reflection prompts in each moral reasoning level that students may have responded to within *Contents Under Pressure* in comparison to the even number of considerations across all moral reasoning levels present within the EPSRI.

3. Results and discussion

As stated previously, the research question guiding this study is *What differences exist between students' expressed moral reasoning when taking surveys and when interacting with a more immersive digital environment?* To determine students' expressed moral reasoning when taking a survey, the EPSRI results, which are shown in Tables 3 and 4, were compiled. The averages obtained for students' moral reasoning level varied between 3.66 for pre-conventional to 4.64 for post-conventional and showed statistically significant differences between all comparisons. Effect sizes varied from 0.37 representing a small effect between pre-conventional and conventional ratings to 1.61 representing a very large effect between pre-conventional and post-conventional ratings. Students rated post-conventional considerations significantly higher than either pre-conventional or conventional considerations with both comparisons showing very large effect sizes.

Table 3. Data collected from the EPSRI.

Moral Reasoning Level	Number of Considerations	Average	Standard Deviation
Pre-Conventional	4	3.66	0.71
Conventional	4	3.91	0.58
Post-Conventional	4	4.64	0.48

Table 4. Results from the EPSRI.

Comparison	p-value (Bonferroni Adjustment Applied)	Cohen's D effect size	Effect size scale (Sullivan and Feinn 2012)
Pre-Conventional → Conventional	<0.0001	0.37	Small
Pre-Conventional → Post-Conventional	<0.0001	1.61	Very Large
Conventional → Post-Conventional	<0.0001	1.38	Very Large

Table 5. Data collected from *Contents Under Pressure*.

Moral Reasoning Level	Number of Considerations	Average	Standard Deviation
Pre-Conventional	13	3.88	0.40
Conventional	35	4.13	0.34
Post-Conventional	14	4.28	0.36

Table 6. Results from *Contents Under Pressure*.

Comparison	p-value (Bonferroni Adjustment Applied)	Cohen's D effect size	Effect size scale (Sullivan and Feinn 2012)
Pre-Conventional → Conventional	<0.0001	0.67	Medium
Pre-Conventional → Post-Conventional	<0.0001	1.07	Large
Conventional → Post-Conventional	<0.0001	0.45	Small

The results of the EPSRI show students predominantly apply post-conventional-based moral reasoning when making process safety decisions. This result may make sense given students are in an academic environment, specifically in the context of a process safety course. However, these results contradict some findings and discussion in literature, which suggests post-conventional-based moral reasoning is not attained until after much experience into adulthood (Rest et al. 1997). Because of this, students who participated in this study may be expected to predominantly display conventional-based moral reasoning although the level of reasoning demonstrated will be

a function of the individual's personal experiences. This difference between theory and practice may be attributed to students' predictive mindset. When in classroom-based environments, individuals tend to forecast their behaviour based on what they think is the most ethical decision (Bazerman and Tenbrunsel 2011; Bodnar et al. 2020). Behavioural forecasting is not inherently unethical, but it tends to lead to unethical behaviour in the future (Osberg and Shrauger 1986). If forecasting behaviours are occurring within the EPSRI, then students' ratings may not necessarily be representative of the types of decisions they will make when they encounter similar situations within industry (Bazerman and Tenbrunsel 2011; Milgram 1963; Burger 2009). These results suggest that traditional methods of evaluating ethics education, such as evaluating paper-based scenarios or case studies, may need to be adapted to address the inherent tendency towards errors in behavioural forecasting.

The *Contents Under Pressure* results are shown in Tables 5 and 6. The averages obtained from students' reflections ranged from 3.88 for pre-conventional to 4.28 for post-conventional. All of the comparisons were statistically significant. The effect size varied from 0.45 representing a small effect between conventional and post-conventional ratings to 1.07 representing a large effect size between pre-conventional and post-conventional ratings.

A notable result from the analysis of the *Contents Under Pressure* data is how small the differences are between the ratings of the different moral reasoning levels. In this context, the spread of the means is only 0.62 in comparison to the spread observed in the EPSRI data, which was 0.98. Previous studies have shown simulations effectively increase student understanding in complex topics among diverse disciplines (Pasin and Giroux 2011; Reiners and Wood 2013). In the context of *Contents Under Pressure*, the results in Tables 5 and 6 show students still rated considerations significantly differently based on the level of moral reasoning, but the effect sizes demonstrate that the differences between the ratings of moral reasoning levels was less impactful within this context. As some of the prompts between the two platforms were not verbally differentiable, as shown in Tables 1 and 2, the decrease in effect size suggests that students may utilise less behavioural forecasting in immersive environments, which is a promising first step towards identifying authentic methods for measuring ethical decision making in engineering contexts.

Visualisations of how the moral reasoning levels changed in students between the EPSRI and *Contents Under Pressure* contexts are shown in Figure 4. All of the comparisons were statistically significant. The effect size varied from 0.37, representing a small effect size within the pre-conventional consideration ratings, to 0.84, representing a large effect size within the post-

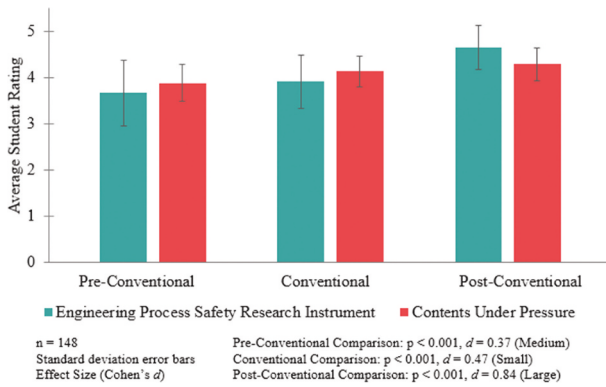


Figure 4. Bar graph comparison between the EPSRI and *Contents Under Pressure*.

conventional consideration ratings. Students' ratings of post-conventional considerations were significantly less in *Contents Under Pressure* than in the EPSRI.

Literature and these preliminary results suggest a difference between student ratings in the contexts of a survey and game. As shown in Figure 4, there was a significant decrease in post-conventional based moral reasoning with a large effect size. This effect may be attributed to the immersive environment creating a more realistic experience for students where they feel integrated into the digital game. In doing so, students may forget they are engaging in an ethics exercise and break away from their predictive behaviour (Osberg and Shrauger 1986). This phenomenon potentially resolves the risk of behavioural forecasting issues (Bazerman and Tenbrunsel 2011; Milgram 1963; Burger 2009).

The goal of *Contents Under Pressure* is not to enhance or reduce the amount of specific forms of moral reasoning students perform in practice. Instead, the goal is to expose students to the complexity of decision making and, perhaps, reveal to them their actual decision making trends and how these conflict with their own predictive decisions as captured by their responses to the EPSRI. As an example of this procedure, student responses to the specified three EPSRI considerations and *Contents Under Pressure* reflection prompts shown in Tables 1 and 2 were compared directly at each moral reasoning level as there was little variation observed in the phrasing of these specific considerations or prompts. Results from this analysis are shown in Table 7.

These results further demonstrate how, within an immersive or authentic context such as *Contents Under Pressure*, students rate the relevance of conventional and post-conventional considerations significantly lower compared to how they rate them in the context of the EPSRI. Other studies on simulation games have similarly shown that students respond differently to ethical decisions within an immersive environment (Duffull and Peterson 2020; Bos, Shami, and Naab 2006; Jagger, Siala, and Sloan 2016). These and additional studies on games within the field of medical ethics (Lorenzini et al. 2015) reinforce how games are beneficial for providing authentic contexts to explore decision making while providing students with the ability to fail without real-world consequences. They also demonstrated that unlike case studies or class-based exercises, the simulation games require students to commit to a decision and then experience the consequences of that choice. Further education in ethics and decision-making, specifically in process safety contexts, should take advantage of games given that this form of simulation elicits more realistic responses from students and can help them with understanding their decision-making processes.

3.1. Study limitations

The data collected represents only three institutions, which may limit the generalisability of the results to other institutions. The EPSRI and *Contents Under Pressure* are designed specifically around chemical engineering and process safety dilemmas; this may limit the transferability of these findings to other fields of engineering. Additionally, the data from the EPSRI only reflects results from the dilemma that showed the best contextual alignment with the digital environment. The trends presented may differ slightly from the moral reasoning level ratings obtained across the entire EPSRI. Within *Contents Under Pressure*, the number of reflection prompts in each moral reasoning level varied for students due to the dynamic decision pathways built into the *Contents Under Pressure* environment. This variance may have influenced the reflection prompt ratings that students selected. Finally, the students' experience may have differed between the EPSRI and *Contents Under Pressure* inherently due to the format of the tools. The EPSRI does not capture

Table 7. Specific consideration comparison between the EPSRI and *Contents Under Pressure*.

Moral Level	Reasoning	Sample size	EPSRI		<i>Contents Under Pressure</i>		p-Value	Effect Size	
			Average	Standard Deviation	Average	Standard Deviation		Cohen's d	Scale (Sullivan and Feinn 2012)
Pre-Conventional		140	4.12	0.93	4.10	0.80	0.850	0.02	Trivial
Conventional		126	4.74	0.57	4.29	0.65	<0.0001	0.75	Medium
Post-Conventional		37	4.78	0.58	4.08	0.49	<0.0001	1.30	Very Large

the impact of time on decision making whereas *Contents Under Pressure* has the opportunity to supply immediate feedback on decisions through metrics and instil a sense of urgency through interactions with characters.

4. Conclusions

A clear difference in student responses is evident when comparing safety decision choices presented in a survey based assessment (EPSRI) and a digital immersive environment (*Contents Under Pressure*). On the EPSRI, students typically expressed a preference for factors related to the post-conventional level of Kohlberg's moral development theory. This behaviour is inconsistent with the expected level of moral development of a college student, but it is consistent with students acting in a predictive mindset when making decisions in a classroom based environment. Within *Contents Under Pressure*, the ethical and safety decisions were situated in a more authentic environment and included the addition of realistic constraints, such as time, productivity, and personal reputation. In this context, students tend to make choices more consistent with the conventional level of Kohlberg's moral development, which is aligned with the expected moral development of college students, and suggests that students make more authentic process safety decisions when making them in a more authentic context. A comparison of identical or near-identical prompts from both the EPSRI and *Contents Under Pressure* reveals that students respond to the information presented to them in a highly contextualised and situated manner, which demonstrates that the enhanced interactivity and authenticity of the game has a measurable effect on their responses.

These findings suggest that evaluations of students' responses to case studies and other safety discussions, while perhaps valuable from a fundamental or historical context, may be limited in their ability to predict students' responses to safety and ethics decisions outside of a testing environment due to their lack of preauthentication. Testing environments, such as evaluating case studies in a classroom, often encourage students to make selections that sound the most correct and many students may overlook the extenuating factors that might disguise ethical decisions in the real world. The case of Williams Olefins and several other industrial accidents show that many safety choices are being made as if they are decisions based primarily on efficiency or profitability, which can lead to catastrophic results. As such, the digital environment may better be able to represent, in real time, the additional pressures that an engineer may face in the field, leading

them to consider additional factors that are difficult if not impossible to replicate in a written case study. As it has been observed that students approach decision-making differently within these two contexts, it is important from a pedagogical standpoint that instructors take the time to debrief and discuss the decisions posed within *Contents Under Pressure*. This will enable students and instructors to engage in meaningful discussions on why decisions within this context may have been approached differently than those observed within the evaluated case studies and provide awareness for how to identify these types of decisions in the future.

Within an immersive and authentic digital environment that adds factors related to time, money, and reputation, students are given the opportunity to make ethical and process safety decisions in a manner that may better mimic scenarios they may experience working industrially. Using a preauthentication approach allows students to practice making decisions and seeing the ramifications associated with their choices in a safe environment. This experience may help students move away from predictive mindsets and help them recognise actual ethical decisions when they present themselves within industry.

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Notes on contributors

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