Using a Game-Based Learning Approach to Help Students Understand the Importance of Ethics in Science

Michael M. Kasumovic[a], Tim Dean[b], and Pietro Pollo[a]

Corresponding author: Michael Kasumovic (m.kasumovic@unsw.edu.au)
[a]School of Biological, Earth, and Environmental Science, UNSW Sydney
[b]The Ethics Centre, Sydney, Australia

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Abstract

Teaching science students about ethics is important given how technology has the potential to provide social and political power. However, providing science students with meaningful ethical experiences is difficult to do at scale. In this study, we use a digital game-based learning approach to provide first year science students with an understanding of ethics. In this game, students are tasked with becoming the commander of a new space colony that must make various decisions for the survival of the colony. After gameplay, students can visualise how their peers answered the game questions. This allows them to see the variation in the responses from their class. Using established surveys, we show that students' ethical perspectives changed as a function of playing the game and reflecting on their experience. We thus highlight and discuss how a game-based learning approach can provide students with ethical experiences to help them better understand the role of ethics in science at scale.

Introduction

Ethics is often defined as the study of moral principles that govern human behaviour and societal activities (Hedayati-Mehdiabadi, 2022). Despite this definition, there is value in distinguishing between morality and ethics. Morality is the set of norms, values, attitudes, and beliefs about what acts are acceptable that guides individual and group behaviour. It is created, maintained and spread by social groups, and individuals are enculturated in their community's morality from a young age. Many aspects of moral thinking are done at an unconscious level, and individuals can struggle to accurately articulate the norms, values, attitudes and moral beliefs that influence their behaviour (Kesebir & Haidt, 2010). In contrast, ethics is the reflective study of how we ought to behave. It is influenced by moral norms and beliefs, but ethics can also be critical of them. Where morality is largely unconscious, ethics seeks to surface it and seek good reasons for action. As such, ethics serves as a cornerstone for discerning right from wrong and guiding individual actions and societal norms (Duncan & Geist, 2020; Haidt & Joseph, 2004; Hedayati-Mehdiabadi, 2022).

There are many different factors that can affect our morals and ethical perspectives. Of all the factors, those associated with culture are arguably the most important (Haidt & Joseph, 2004). Evidence suggests that individuals from Western Educated Industrialised Rich and Democratic (WEIRD) societies exhibit more individualistic moral views compared to non-WEIRD societies, which tend to be more communitarian or religious (Henrich, Heine, & Norenzayan, 2010). Other factors known to affect individual morals are political ideology (McAdams et al., 2008), as well as psychological factors such as personality (Ellemers, van der Toorn, Paunov, & van Leeuwen, 2019) and cognitive style (Zmigrod, Eisenberg, Bissett, Robbins, & Poldrack,

2020). In the same vein, male and female students often exhibit different tendencies towards ethical behaviour, with notable variations in their approach to ethical dilemmas and moral reasoning (Keller, Smith, Smith, Murphy Smith, & Smith, 2007; Selvalakshmi & Mutharasi, 2017). Together, these factors demonstrate that our morals are a result of the interaction of various factors.

What is also interesting about our morals and ethical perspectives is that they continue to change as a function of our experiences. Graduate students and students with greater work experience tend to exhibit less egocentric attitudes compared to undergraduates, suggesting that higher levels of education influence ethical viewpoints (Keller et al., 2007). Psychology students with more fieldwork experience rate their training in ethics significantly higher (Duncan & Geist, 2020) and exhibit less egocentric attitudes (Keller et al., 2007). Additionally, although computer IT students with greater computer skills behave more unethically according to established IT ethical rules, this unethical behaviour decreases when students gain a better understanding of these IT ethics (Ulman, Harris, Marreiros, Quaresma, & Ganiyev, 2019). Overall, these studies suggest that education and practical exposure in a professional setting can significantly influence and mature an individual's approach to ethical decision-making. This is likely because explicit ethics training, which surfaces moral attitudes and beliefs and provides ethical frameworks for decision making, can contribute to improved ethical decisions.

As educators our role is to prepare students for a future in a rapidly changing world where ethics is likely to play an important role. As such, we should be exploring ways to provide students with opportunities to gain greater exposure and experience that helps them to positively shape their ethical perspectives (Ulman, Harris, Marreiros, Quaresma, & Ganiyev, 2019). Although work experiences are optimal, organising placements for students at scale is difficult and time consuming. In response to this challenge, educators have turned towards other more scalable approaches that offer opportunities for students to gain experience. For example, guest speakers and group discussions are effective in teaching ethics, highlighting the need for engaging and relevant content in ethics education (Sexton & Garner, 2020). Others have used popular comics to approach conversations about ethics (Gerde & Foster, 2008). The advent of digital technologies has also allowed digital simulations (Hedayati-Mehdiabadi, 2022) or virtual reality (Mahfud Sholihin et al., 2020) to provide safe yet realistic environments for students to navigate ethical dilemmas. These novel approaches, particularly those utilizing technology, not only diversify the methods of exploring ethics but also make the field more accessible and relevant to contemporary audiences. They represent a significant shift from traditional, text-based ethical studies to more dynamic and interactive forms of learning and research, reflecting the evolving nature of ethical exploration in the digital age.

The necessity for science students to explore ethics is rooted in the evolving nature of scientific challenges and the societal responsibilities that come with scientific knowledge. The exploration of ethics in science education is not just about understanding the moral principles but also about applying these principles in real-world contexts, thereby shaping a more conscientious and responsible scientific community (Reiss, 1999; Sadler, Klosterman, & Topcu, 2011). As science education broadens to include not only pure science but also its applied and societal aspects, integrating ethics into science education becomes essential (Reiss, 1999).

Our primary goal in this study is to explore whether using a game-based learning approach coupled with student-led real-time data analysis affects student ethical perspectives by encouraging students to reflectively engage with their moral attitudes and beliefs. We chose a

game-based approach because it is experiential, engaging, accessible, and scalable across cohorts of students. Our secondary goal is to understand how students felt about using a game-based approach in learning about ethics.

In this game-based learning approach, students were placed in the role of a commander of a new space colony. Hypothetical and fictional examples are useful to take subjects out of their contingent proximate circumstances and assists them in thinking about ethical issues without the baggage of direct prior experience or local contexts that could trigger unreflective moral responses. Fiction also allows the author to craft a scenario that presents a very specific and targeted dilemma for the subject to address. Students were tasked with answering 18 different ethical dilemmas (see Supplementary Materials for more information). Each student's answers to these dilemmas were recorded, aggregated, and then visually provided for a cohort of students to explore after gameplay. This allowed students to use a data-driven approach to understand the variation in responses to the dilemmas within their cohort. Before and after gameplay, students completed the Ethical Position Questionnaire (EPQ-5; O'Boyle & Forsyth, 2021) to explore whether this approach altered student sensitivity to harm (idealism) and moral standards (relativism). Students also completed an Importance of Ethics in Science Survey about their perspective on the importance of ethics in science modified from Keller et al. (2007).

Methods

Participants and design

The pre-existing data for this study were provided by Arludo, an educational game development company according to UNSW Human Research Ethics Committee. Data provided consisted of anonymised student answers from digital worksheets coupled with in-game choices from the game *Ethos 2514*.

Before playing the game, each participant completed a digital worksheet that contained a pre-game EPQ-5 questionnaire, and an Importance of Ethics in Science Survey. Students then individually played the game *Ethos 2514*. Once complete, students were given an opportunity to explore the answers from their cohort that were aggregated and visualised after completion of the game within student worksheets. Students could thus see how others in their cohort answered the same questions and could see the variation in answers throughout the game. Students were asked to reflect on one of the dilemmas within the game and explain why they thought the variation in answers existed and why they felt students answered differently to them. Students were then asked to reflect on their experience, after which they once again completed the EPQ-5 questionnaire and the Importance of Ethics in Science Survey.

Participants consisted of a total of 664 first year university students from five different cohorts between 2023 and 2024 (Table 1). There was variation in the number of students completing the game and each of the surveys in each cohort and year. First, as the game was played through a mobile device outside of the worksheet, there were certain individuals whose game data could not be matched to their worksheet, and therefore, survey completion. This explains why the sample size of game completion is always lower than survey completion in each cohort. Second, as the worksheets were created by Arludo (a third party) and shared with researchers after the fact, we had no control over which surveys were used. The EPQ-5 was not used by Arludo in 2023 cohort 3, and the IESS survey was only added in 2023 cohort 3 and used subsequently. It is also important to note that the students used in this study, although from

diverse cultural backgrounds, largely fall into the WEIRD classification outlined by Henrich et al. (2010).

Table 1: The sample size of students from each cohort and each year, and the survey data collected from them. The N is the sample size of students that played the game to completion and pushed their game results. EPQ-5 N is the number of students that completed the EPQ-5 survey, and the IESS N refers to the number of students that completed the Importance of Ethics in Science Survey

Year	Cohort	N	EPQ-5 N	IESS N
2023	1	108	124	0
2023	2	128	152	0
2023	3	90	0	94
2024	1	123	142	142
2024	2	131	132	132

Game-based learning approach

Ethos 2514 is a choose your own adventure style of game in which players are assigned the role of Commander of a new colony settled on a new planet. It can be freely downloaded from the Google Play or Apple App Stores. Within the game, players encounter 17 different ethical dilemmas: 10 minor dilemmas and 7 major dilemmas. The minor dilemmas were non-moral, low stakes, and more related to conventions and social norms. The major dilemmas were based around moral conflicts, were high stakes, and went beyond social norms. The full list of dilemmas, and the available choices can be found in the Supplementary Material. While students engage with the game, they meet diverse characters in different roles (e.g., engineer, botanist, scientist) that provide them with information to help players decide how they will answer each moral dilemma. Each of these non-player characters were designed to have a specific moral archetype that could resonate with players to help them make decisions. The game is a linear story and takes approximately 25 minutes to complete.

Along with experiencing the game themselves, all the choices made by a cohort are anonymously aggregated and visualised as graphs to allow students to see the choices made by their cohort (example graphs can be found in the Supplementary Material). Thus, once students complete the game, they can explore how other students answered the same questions. This provides students with the opportunity to see the variation in answers from their cohort and to reflect on how or why the answers varied from their own.

Ethical Position Questionnaire

Students from two cohorts from 2023 and another two cohorts from 2024 completed the Ethical Position Questionnaire (EPQ-5; O'Boyle & Forsyth, 2021) before and after playing *Ethos 2514*. This is a 10-item questionnaire explores a participant's sensitivity to harm (idealism) and moral standards (relativism); the questions are in the Supplementary Materials. Ethical position theory posits that individuals exhibit a spectrum of idealism and relativism with different combinations of each determining your ethical position (O'Boyle & Forsyth, 2021) (Figure 1).

Table 2: The four moral types outlined in the EPQ and their relationship.

	Low Relativism	High Relativism
Low Idealism	**Exceptionalists**: Individuals that are willing to accept exceptions to moral standards if the benefits outweigh potential harms	**Subjectivists:** Individuals that do not uphold moral standards defining right or wrong, nor do they prioritize avoiding harmful consequences
High Idealism	**Absolutists**: Individuals that are principled in their ideals, advocating for both adherence to moral standards and the mitigation of harm to others	**Situationists:** Individuals that prioritize minimizing harm over strict adherence to moral standards, viewing moral judgment within its contextual framework.

Idealism focuses on humanitarian and visionary ideals, like preventing harm to others, while relativism questions the reliance on moral rules or codes of ethics in making moral judgments. The EPQ-5 thus allowed us to understand how students changed in their perspectives of idealism and relativism after engaging with the game-based learning approach and the data from their cohort.

The Importance of Ethics in Science Survey

To explore how science students perceive the importance of ethics, we asked students to respond to the Importance of Ethics in Science Survey modified from Keller et al. (2007) using a 5-point Likert scale (it can be found in the Supplemental Materials). Details regarding the modifications from the original survey can be found in the Supplementary Materials. The statements were designed to allow the research team to judge the standards by which the students made ethical judgments and included statements which could be placed under the categories of utilitarian, religious, deontological, hermeneutical, amoral, and egoistic. The amoral category argues that science and ethics are not related.

Statistical analyses

We performed all our analysis using R 4.2.2 (R Core Team, 2022). Given that all questions from questionnaires were in a Likert 5-point scale, we performed ordinate logistic regressions using the function *clmm* from the package *ordinal* (Christensen, 2011) to analyse students' responses to these questionnaires. We analysed EPQ-5 responses from its two sets of questions (idealism and relativism) separately, so we fitted three different models in total (EPQ-5 set 1, EPQ-5 set 2, and the Importance of Ethics in Science Survey. In all models, we used time (after playing the game vs. before playing the game) as the sole predictor variable, and response ID and class ID as random factors. We based our inferences on the 95% confidence interval for the coefficients in these regressions, but we also provide p-values based on z-values from the models.

Results

The distribution of student responses for each dilemma from each cohort can be found in Figure 1.

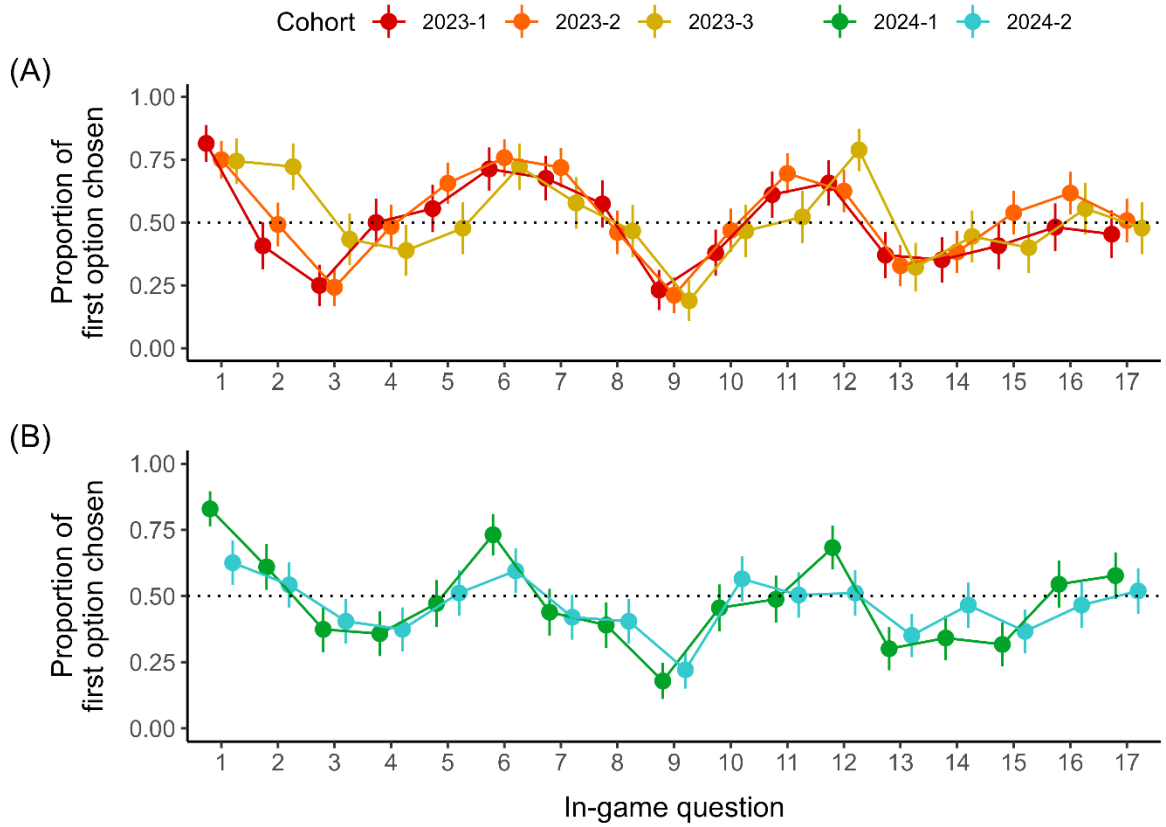

Figure 1: The proportion of students that chose the first of two options in each of the ethical dilemmas in each cohort of 2023 (A) and 2024 (B). The dotted line highlights the scenario in which cohorts were equally divided on how the answered questions.

For the EPQ-5 questionnaire, we found that students' responses to the first set of questions of the EPQ-5 questionnaire (idealism) decreased after playing *Ethos 2514*. In contrast, students' responses for the second set of questions of the EPQ-5 questionnaire (measuring relativism) increased after playing *Ethos 2514* (Figure 2, Table 3). Our results thus demonstrate that students' became more subjectivist in their ethical perspectives by lowering their idealism and increasing their relativism.

Table 3. Results from ordinate logistic regressions comparing students' responses in the EPQ-5 after vs. before playing *Ethos 2514*. The sample size is 550 students.

Questionnaire	Estimate	Standard error	95% confidence interval	z-value	p-value
EPQ-5, idealism set	-0.844	0.055	-0.951 to -0.737	-15.473	< 0.001
EPQ-5, relativism set	0.327	0.05	0.228 to 0.425	6.51	< 0.001

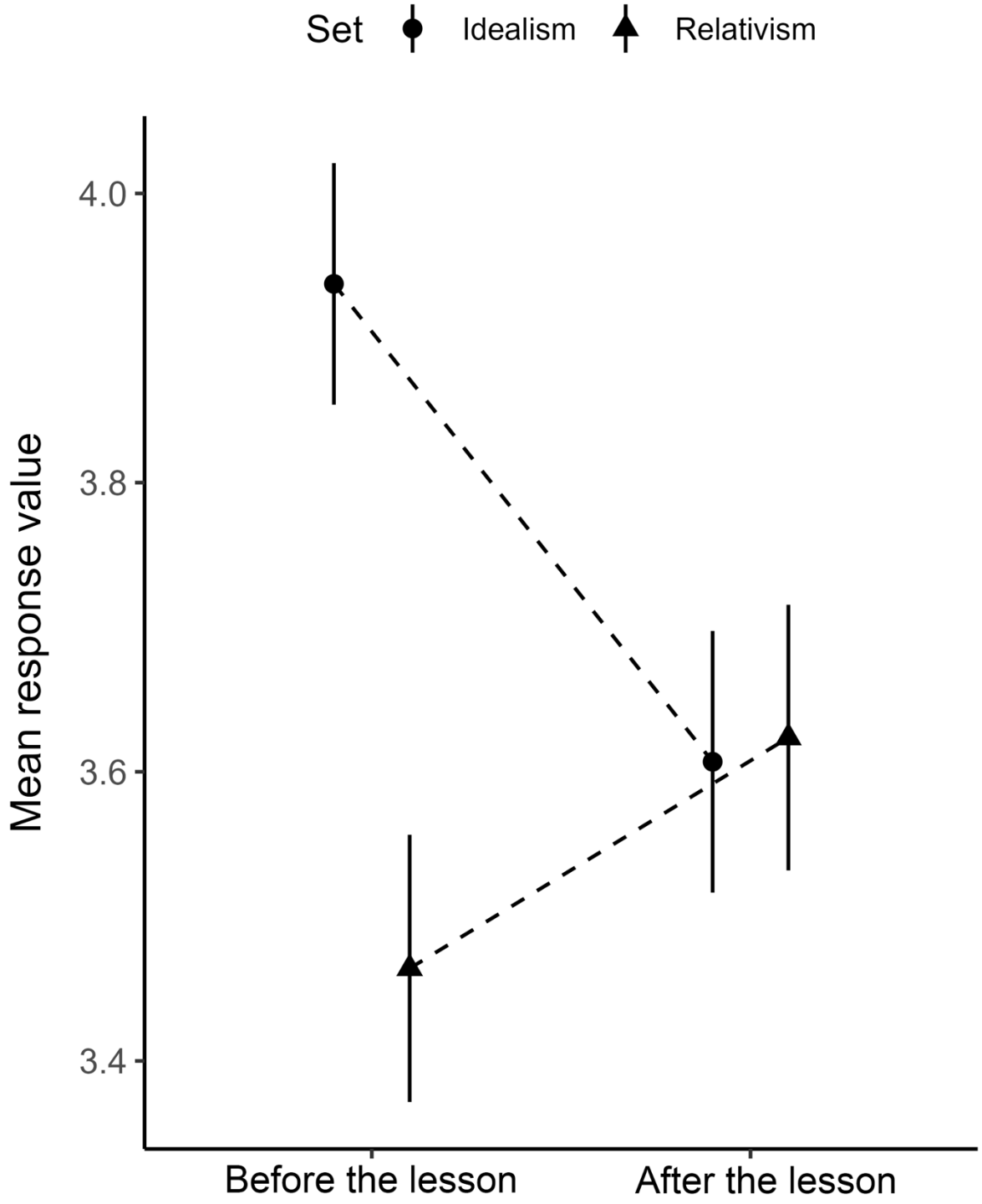

Figure 2: The mean change before vs. after lessons in responses for the idealism set and the relativism set of EPQ-5 questions in each cohort. Student scores in idealism decreased after playing *Ethos 2514*, while student scores in relativism increased after gameplay. Dotted line highlights no differences. Although cohort differences are controlled by adding the random effect of cohort, this creates a single total average that is explored statistically. We plot the average across cohorts here to match Table 3. Error bars are 95% confidence intervals.

We found that students' mean answers on the Importance of Ethics in Science Survey decreased after playing *Ethos 2514* (Figure 3, Table 4). As we saw an overall decrease in the importance of ethics, we further explored each pair of questions using a post-hoc test according to their designation: utilitarian, religious, deontological, hermeneutical, amoral, and egoistic. We found a decrease in amoral, deontological, hermeneutical, and utilitarian perspectives and an increase in an egocentric perspective after compared with before gameplay (Table 4). Conversely, we did not detect differences in religious perspectives (Table 4).

Table 4: Results from ordinate logistic regressions comparing students' responses in the Importance of Ethics in Science Survey after vs. before playing *Ethos 2514*. We also explored each of the ethical domains individually. The sample size is 368 students.

Questionnaire	Estimate	Standard error	95% confidence interval	z-value	p-value
Importance of Ethics in Science Survey	-0.124	0.038	-0.199 to -0.049	-3.233	0.001
Amoral	-0.332	0.112	-0.55 to -0.113	-2.971	0.003
Deontological	-0.202	0.1	-0.398 to -0.05	-2.014	0.004
Egoistic	0.362	0.098	0.17 to 0.554	3.695	< 0.001
Hermeneutical	-0.47	0.096	-0.658 to -0.282	-4.892	< 0.001
Religious	-0.114	0.316	-0.335 to 0.108	-1.006	0.192
Utilitarian	-0.285	0.096	-0.473 to -0.096	-2.963	0.003

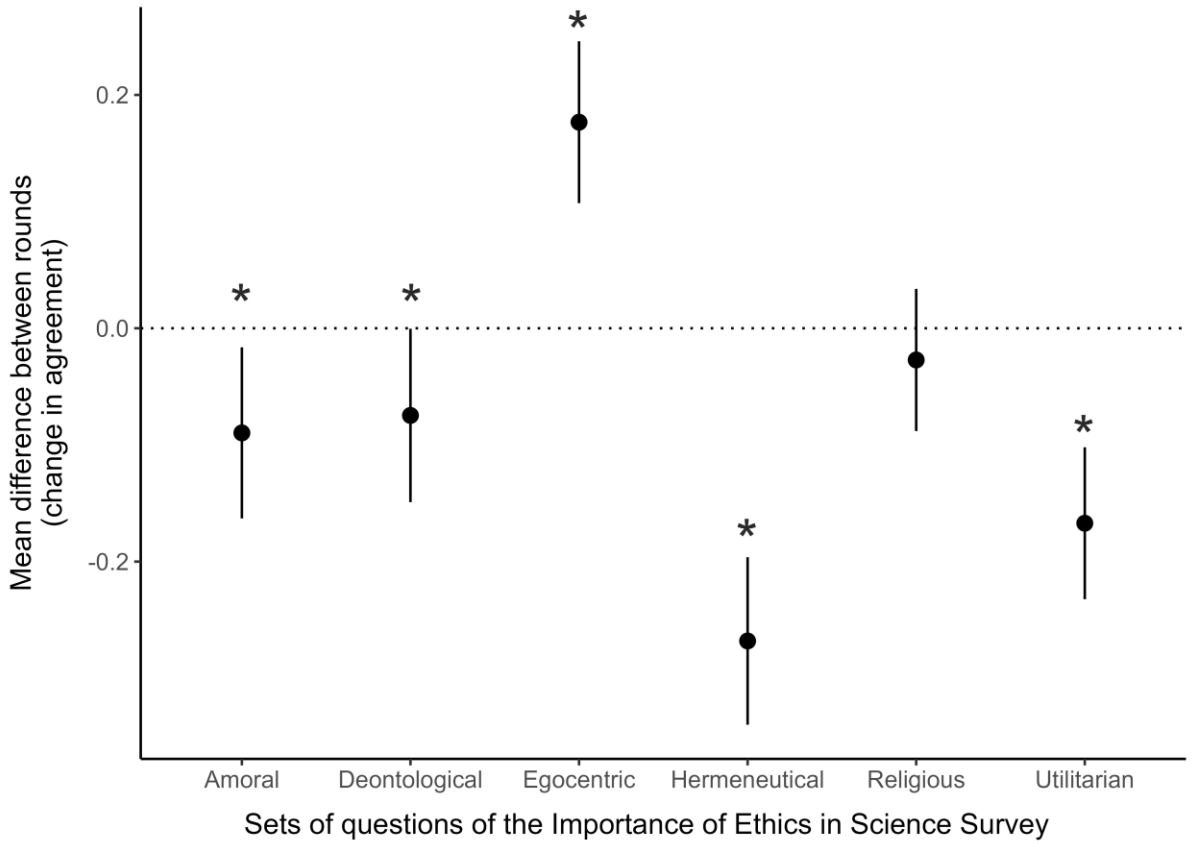

Figure 3: The mean change in Importance of Ethics in Science Survey responses before vs. after lessons in each cohort. The asterisk denotes statistical significance ($\alpha \leq 0.05$, see Table 4). Dotted line highlights no differences. Although cohort differences are controlled by adding the random effect of cohort, this creates a single total average that is explored statistically. We plot the average across cohorts for each question set here. Error bars are 95% confidence intervals.

Discussion

In this study, we explored whether a game-based approach to learning ethics coupled with real-time presentation of variation in student responses affected student ethical perspectives and their perspectives on the importance of ethics in science. We found that students became subjectivists in the ethical perspectives (Figure 2) and that their perspectives on the importance of ethics in science decreased after the lesson (Figure 3). We discuss our results further below.

Students' answers to the Ethical Position Questionnaire (EPQ-5; O'Boyle & Forsyth, 2021) showed that they decreased in idealism after lessons, meaning that students shifted away from an idealist belief and became more pragmatic or realistic about how the world functions. In other words, students gave a lower priority to harm or benefit compared to other considerations. Students also increased in their relativism, meaning that students realised that what is right or wrong can vary for different individuals and gave a lower priority to universal standards or norms. As a result, we saw students shift towards becoming more subjectivist; the idea that there are no universal moral standards and that what is right or wrong is subjectively determined by individual experiences (O'Boyle & Forsyth, 2021). It is possible that this shift in attitudes was due to the students being exposed to a diversity of responses from their cohort in response to dilemmas that had no clear and obvious solution, such that all responses could be defended with plausible ethical reasons. As such, although they answered in one way, they became more accepting that there was no "right" answer and that different individuals could hold different valid ethical beliefs.

We also saw an overall decrease in the Importance of Ethics in Science survey. When looking more closely this occurred because of a decrease in the amoral, deontological, hermeneutical, and utilitarian domains, despite an increase in the egocentric domain (Figure 3). While real-world experience by graduate students fieldwork experience by psychology students results in a decrease in egocentric attitudes (Keller et al., 2007), we saw the opposite in our results. This could suggest that the dilemmas caused the students to question prior ethical beliefs that appeal to universal principles (utilitarianism), objective truth (hermeneutics), duty (deontological) and resort to more personal standards and goals (egoism). Interestingly, we also saw a decrease in the amoral domain which posits that students saw less of a relationship between ethics and science; however, we feel this is a result of students accepting that others may have different moral beliefs to themselves. There was no change in religion between the surveys. Regardless, the experience provided by the game-based approach thus seems to offer similar benefits to other means of engaging students in ethical discussions (Gerde & Foster, 2008; Sexton & Garner, 2020; Ulman et al., 2019) and was found to be engaging by the majority of students (Figure 4).

Although the decrease in the Importance of Ethics in Science survey can be seen as a decrease in students feeling that of how important ethics is on science, taken with changes in the EPQ-5, we argue that students are re-examining their relationship with ethics and that this re-examination is resulting in a reconstruction of connection between ethics and science. Such a

reconstruction is what we would expect to see when students are learning and gaining new information and has been identified as cognitive conflict (Kowalski and Taylor, 2009). This cognitive conflict has been demonstrated by Kingsley, Oliver and Slavic (2019) in reference to science communication where participants' understanding of science was shown to decrease after a live science communication event. This suggests that exercises such as a game offering ethical dilemmas is not an end point of ethical education but a starting point. The game serves the function of what Mezirow (1991) calls a "disorienting dilemma". This is a situation that challenges the students' assumptions and puts pressure on their intuitive responses, triggering reflection and opening them up to the possibility of "transformative learning" (Mezirow, 1991). In the case of ethics in science, it can make students receptive to new frameworks for ethical decision making.

We argue that there are two reasons for our results. First, through the use of a game-based approach, we engaged students in having to make difficult ethical decisions while performing a leadership role. This imagining of a role coupled with the ability to see how other students responded to the exact same situations allowed students to gain an understanding that different people can respond to ethical dilemmas in different ways, and each can seem plausible or justifiable. It opened their mind to the possibility that there might be more than one valid answer to particular problems and the acceptance that different individuals may find a distinct solution to the same dilemma. This, in turn, could make them receptive to learning new language to help them understand the different ethical perspectives as well as new ethical decision-making tools. Further studies using non-WEIRD populations (Henrich et al., 2010) are now necessary to determine whether our results could be generalizable across different populations.

There are obvious limitations to our approach as well. First, although we show these differences in the short term (i.e. over the period of a single tutorial), we do not know how long these effects will last. Further research that demonstrates a change in attitude and then a re-examination of how long this change in perspective lasts is necessary. It is very likely that students would need to be encouraged to continually reflect about their decisions to bring about any long-term effects. Nonetheless, our results do demonstrate that a game-based approach is useful in facilitating early perceptual changes. Second, further studies trying to disentangle the effect of the game-based approach and the reflection of the experience would prove fruitful. Although we argue that it is both experiences that are necessary for students to experience a change in perspective, adding a no-game or no-reflection treatment in the experimental design would allow us to determine the relative importance of each aspect towards altering student perspectives. Future research should explore this idea to understand how to maximise student experiences in the classroom.

Our results thus highlight that engaging students in a way that allows them to experience new perspectives that challenge their own views can lead to a successful shift in understanding. Technology was clearly part of that role, but it was not the technology itself, but the use of technology to allow an individual to see how others behaved. This is not surprising given that we learn from our own experiences and through the interactions with others. We thus argue that technology that connects students and provides them with experiences they could not normally engage in is where technology will have the most value in education.

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