Improving Undergraduate Attitudes Towards Responsible Conduct of Research Through an Interactive Storytelling Game

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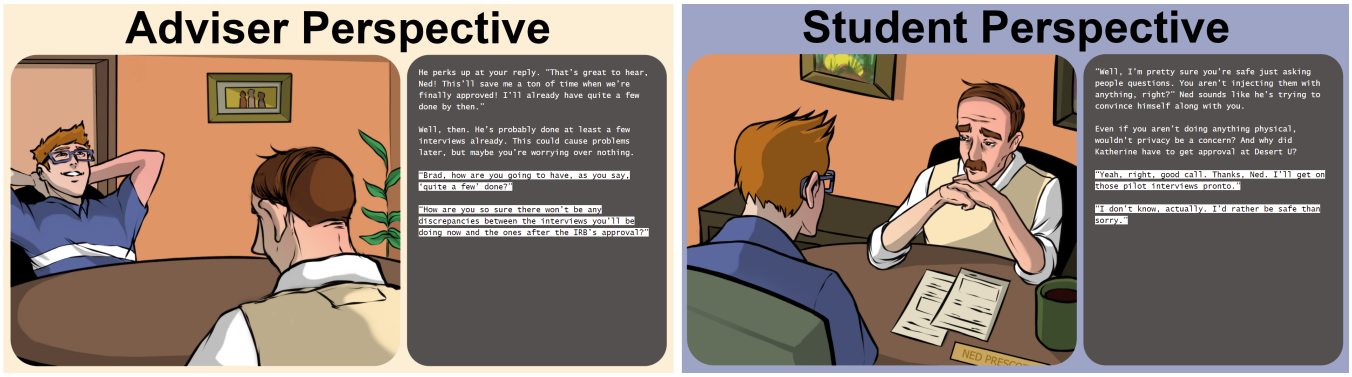

Figure 1: Two perspectives and corresponding choice points from *Academical*'s first scenario, "The Head Start." In this story, the player can role-play as an adviser or a graduate student struggling to navigate the human subjects research approval process. The two highlighted text blocks from each scene represent the player's dialogue options.

ABSTRACT

Responsible conduct of research (RCR) is an essential skill for all researchers to develop, but training scientists to behave ethically is complex because it requires addressing both cognitive (i.e., conceptual knowledge and moral reasoning skills) and socio-affective (i.e., attitudes) learning outcomes. Currently, both classroom- and web-based forms of RCR training struggle to address these distinct types of learning outcomes simultaneously. In this paper, we present a study providing initial evidence that playing a single brief session of *Academical*, a choice-based interactive narrative game, can significantly improve players' attitudes about RCR. We further demonstrate the relationship between engagement with the game and resulting attitudes. Combined with our previous work showing *Academical*'s advantages over traditional RCR training for teaching cognitive learning outcomes, this study's results highlight that utilizing a choice-based interactive story game is a uniquely effective way to holistically address RCR learning outcomes that drive ethical research behavior.

CCS CONCEPTS

• **Human-centered computing** → **User studies**.

KEYWORDS

attitudes; engagement; choice-based; role-playing; interactive storytelling; narrative game; education; responsible conduct of research

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1 INTRODUCTION

It is essential that all researchers learn how to conduct their work ethically, but teaching responsible conduct of research (RCR) is complex and therefore not always effective [5, 50]. Specifically, being able to successfully navigate ethical dilemmas requires mastery of a combination of distinct learning outcomes, including relevant conceptual knowledge (i.e., sensitivity to societal expectations), moral

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reasoning skills (i.e., judgement of possible solutions) and positive attitudes about RCR (i.e., motivation to behave ethically) [5, 8, 28]. While past work evaluating traditional RCR pedagogy has successfully explored developing knowledge and moral reasoning skills, improving attitudes is relatively understudied and underemphasized for current RCR training methods [29, 45, 53]. Conversely, narrative (regardless of medium) has been demonstrated as an extremely effective tool for changing an individual's attitude [10, 16, 57]. Interactive narrative (i.e., digital "choose your own adventure" storytelling) has been implicated to have the same beneficial effects for impacting values [21], but currently there are very few peer-reviewed reports of empirical studies that directly support this expectation [43, 56]. Existing work has demonstrated the potential for choice-based storytelling games to foster attitudes involving personal or social change (e.g., improving health habits or increasing empathy for marginalized groups of people), but the efficacy for this particular medium to change attitudes about the value of professional ethics training (specifically RCR) remains unknown. This paper seeks to extend the evidence supporting interactive narrative for improving ethically-relevant attitudes, particularly within the context of RCR training.

RCR pedagogy research has not yet empirically demonstrated a single form of training that can simultaneously improve all three key RCR learning outcomes (knowledge, moral reasoning skills and attitudes). As a result, RCR courses often employ multiple types of passive or active learning activities (e.g., lectures, case study discussion and role-play) in an attempt to maximize training efficacy. Development of an RCR training method (especially one that is digitally automated) that can address this issue would be a valuable tool to supplement existing training standards. Our previous research showed that *Academical*, an interactive choice-based narrative game, was overall a more effective tool than traditional web-based training for engaging university students and teaching them RCR knowledge and moral reasoning skills [38, 39]. Importantly, that study was the first to empirically demonstrate the value of an interactive narrative game for training moral reasoning skills. In this study, we explore whether playing a single brief session of *Academical* can also significantly improve players' attitudes about RCR. A positive result would indicate that *Academical*, and more broadly interactive narrative games in general, can effectively train all three key abilities that drive improvements in the most important learning outcome of all: ethical behavior. We also investigate the relationship between players' engagement with the game and their attitudes about RCR. We conclude by discussing how this study supports the design and use of interactive storytelling games to improve learning outcomes of ethically complex content.

2 RELATED WORK

2.1 Typical Effects of Traditional RCR Training on Students' Attitudes

Training scientists to recognize and engage in ethical behaviors is critical to improving the quality of research, encouraging healthier workplace practices and increasing the general public's trust in the scientific process [26]. The incidence of reported cases of research misconduct has been increasing since the formal institution of RCR training standards [40]. While there are many possible reasons for this trend, it nonetheless highlights the importance of ensuring RCR training efficacy.

RCR training experts advocate that the best pedagogical methods both teach relevant cognitive skills and foster positive attitudes about research ethics [20]. The logic follows that teaching cognitive skills is only useful if the student also has the affective motivation to apply them [27]. Despite the recent emphasis on attitudes as a critical learning outcome for driving ethical behavior, there is limited research directly evaluating the extent to which traditional RCR pedagogy improves students' attitudes [3]. To add to this research, this paper focuses on evaluating whether playing *Academical*, a web-based interactive narrative game, can improve students' attitudes about RCR.

Self-administered online training courses have recently become a staple for supplementing institutional RCR education, but very little data has been reported about their efficacy for improving RCR attitudes [44]. Studies evaluating the efficacy of classroom-based instruction for improving RCR attitudes have reported mixed results. Powell, Allison and Kalichman showed that in-person training significantly improved students' RCR knowledge but not their attitudes [45]. Plemmons, Brody and Kalichman showed that trainees found their training was beneficial, but that it was significantly more effective for teaching knowledge over skills or attitudes. [44]. To explain this result, those authors surmised that many of the participants had extensive research experience and likely entered the course with well-formed attitudes and skills, thus making those learning outcomes resilient to change. Supporting this idea, another more recent study showed that graduate students (with limited research experience) were significantly more likely to endorse ethical research practices after completing a 10-lecture course [59]. While these studies are valuable for understanding the efficacy for in-person training to improve RCR attitudes, it is difficult to generalize these results due to the limited breadth of research on the topic and the lack of consistent measurement tools or test conditions. Overall, there does appear to be some evidence indicating that traditional RCR pedagogy can improve attitudes, but experts still advocate that education efforts should place more emphasis on targeting this particular learning outcome [27].

2.2 Role-Play is an Effective Method for Training Attitudes in RCR

Reviews examining the pedagogical efficacy of RCR training methods strongly recommend that learning activities should be engaging and promote thoughtful consideration and discussion of relevant ethical issues [4, 27]. Role-play provides an engaging opportunity for students to embody contending perspectives on an issue, making it one of the most promising discussion methods for improving comprehension and execution of ethical behavior [11]. This style of active learning is effective for stimulating role-players' emotions, helping learners evaluate how their own feelings align with the goals of the exercise and thus identify areas for improvement [23]. Much research has shown that live-action role-play is capable of training each of the three learning outcomes (knowledge, moral reasoning skills and attitudes) that drive improvements in behavior [46], including for (but not limited to) topics involving ethical issues like medicine [54, 62], environmental sustainability [52] and

accounting [58]. While these observations are encouraging, it is important to note that role-play activities are not always effective for improving attitudes [47, 60].

The NIH's RCR training mandate specifies that "reflection on responsible conduct of research should recur throughout a scientist's career" [37]. Unfortunately, traditional role-play activities are relatively resource-intensive because they require experienced guidance from an instructor combined with substantial time spent with a partner to practice necessary skills. Therefore, despite its pedagogical efficacy, classroom-based paired role-play is not a particularly convenient method for training ethical behavior. However, there are a number of works supporting the idea that a single-player role-playing video game could improve students' attitudes for a wide range of ethical topics [1, 21, 51], leading us to predict that *Academical* would be effective for improving attitudes about RCR specifically.

2.3 *Academical* is Effective for Teaching RCR Learning Outcomes

In a prior study, we hypothesized that the choice-based, role-playing nature of interactive storytelling games could be employed to improve student engagement as well as knowledge and moral reasoning skills important for RCR. This prediction inspired the development of *Academical*, a choice-based interactive narrative video game (accessible from any web browser) that presents a set of nine stories addressing the nine core RCR topics identified by the NIH—see Figure 1 for a story sample and [38, 39] for a more in-depth description of the game design and rationale. In this single-player game, learners role-play through both perspectives in an ethical dilemma, challenging them to make a series of difficult choices in order to reach an optimal solution. We initially conducted a randomized group comparison study showing that *Academical* is overall more effective than traditional web-based RCR training tools at engaging students and teaching them knowledge [39] as well as skills important for RCR such as moral reasoning [38]. Our successful results, combined with existing evidence that role-playing activities are useful for improving socio-affective learning outcomes, indicate that *Academical* would likely also be able to train improvements in players' attitudes about RCR.

2.4 Engagement and Attitudes

Training can become more effective through gamification, which motivates the student to be more engaged with the learning activity [15, 57]. Engagement, which involves sustained attentional effort, is key for improving long-term learning outcomes, especially affective outcomes like attitudes [35, 49]. Presently, much of the serious games research for academic achievement focuses on math [7, 19, 30], health [6, 24, 34, 61], and problem solving skills [12, 17, 25, 55]. These studies exemplify that gamifying training can increase students' engagement with the material and their motivation to learn and perform. Narrative has become an especially effective method for improving engagement and deep learning [48]. Contrasted with the passive reading study strategy promoted by the majority of existing web training tools, *Academical* utilizes narrative role-play and interactive choices to challenge the player to successfully navigate various moral dilemmas common to scientific research.

Our previous work showed that playing *Academical* was significantly more engaging *and* generally resulted in better RCR learning outcomes compared to traditional web-based training [38]. While the exact cause for players' motivations or capability to perform are unknown, the game demonstrates a clear engagement advantage which may contribute to learning outcome achievement. Our prior engagement results, combined with a field of work showing the relationship between engagement and socio-affective learning outcomes, led us to hypothesize that engagement while playing *Academical* would predict participants' post-game attitudes. Finding a relationship between players' engagement and their post-game attitudes towards research ethics would provide further evidence supporting the game's pedagogical efficacy and provide further support for the connection between engagement and achievement in game-based learning (GBL).

3 METHODS

For this study, we hypothesized that 1) a choice-based interactive narrative game (i.e., *Academical*) would improve players' attitudes towards RCR and 2) players' reported engagement playing the game would predict their post-game attitudes. In order to explore these hypotheses, we conducted a quasi-experimental within-subjects study comparing participants' RCR attitudes before and after playing a single short session of *Academical* as well as comparing those attitudes with their feelings of engagement with the game.

3.1 Procedure

This study was approved by the Institutional Review Board of the University of California, Santa Cruz (UCSC). The study was conducted entirely online and consisted of three major components. One group of study participants was required to 1) complete a pre-game survey assessing demographics and attitudes about RCR, 2) play the *Academical* game, and 3) complete a post-game survey gauging their attitudes about RCR and their feelings of engagement with the game.

3.2 Participant Recruitment

All participants were recruited from an undergraduate course offered through the engineering department at UCSC (a Tier 1 research university). Two weeks before the conclusion of the course, participants were informed of the study through email and offered extra credit toward their class grade in exchange for completing all parts of the study. Participants were told that the purpose of the study was to test the efficacy of a new RCR training program.

A total of 99 undergraduate students registered for this study through a participant recruitment website hosted by the authors' university. Within this pool, 69 successfully participated by completing all parts of the study. Nine of these participants reported that they had received prior RCR training and were therefore excluded from analysis. Of the 60 remaining participants, there were 41 males, 16 females and 3 non-binary. The average participant age was 20.6±2.2 years (median: 20, range: 18-29), which is a typical age for university students who are starting to engage in research and consider applying to graduate school.

Table 1: Participants' attitudes before and after playing a single short session of *Academical*. Responses were measured using a 7-point Likert scale. The table contains mean scores, standard deviations, paired t-test scores (two-sided Wilcoxon sign rank test using 95% CI), and effect size—which is small to medium for significant differences. Items borrowed from [28] are indicated with †.

	Pre		*Post*		*Sig*	*ES*
Attitude Survey Items	μ	σ	μ	σ	p	d
(1) How important is RCR training to you?	4.2	1.5	5.0	1.5	**<0.001**	**0.49**
(2) How important do you think RCR training should be for researchers?	5.7	1.2	6.3	1.0	**<0.001**	**0.57**
(3) Research ethics is serious and deserving of the attention of all researchers. †	6.1	1.0	6.5	0.9	**0.01**	**0.35**
(4) Researchers have a personal responsibility to model and promote RCR. †	5.5	1.1	6.1	1.0	**<0.001**	**0.51**
(5) Researchers have a responsibility to society. †	5.6	1.2	6.0	1.1	**<0.001**	**0.37**
(6) Excellence in research includes RCR. †	5.6	1.2	6.2	1.0	**<0.001**	**0.55**
Overall Attitude Score	5.3	0.9	5.9	0.9	**<0.001**	**0.65**

Participants reported pursuing the following undergraduate degrees: Arts and Design: Games and Playable Media (n = 25), Computer Science: Computer Game Design (13), Cognitive Science (9), Computer Science (7), Technology and Information Management (4), Economics (1), Film and Digital Media (1), Physics (1), and Sociology (1). Two participants reported that they had not yet declared a major, while four reported pursuing two majors. Design-based (26) and engineering (24) degrees were the most common, followed by science (11) and economics (1).

3.3 *Academical* Gameplay

Participants accessed the surveys and game using the same methods as the previous *Academical* study [38, 39]—through their preferred web browser on their personal computers and without any supervision beyond automated data collection. Similarly, the same two (of the nine possible) scenarios were selected for students to play through (i.e., peer review and authorship). Participants were instructed to play through each character at least once in each scenario—equating a minimum of 4 total playthroughs (2 per module)—before completing the post-survey.

3.4 Assessment Tools

3.4.1 RCR Attitudes Survey. To assess *Academical*'s efficacy for improving attitudes about RCR, we created a short survey using a list of attitude goals that are highly recommended by RCR instructors [28]. This survey included six items (two questions and four statements, see Table 1) with possible responses along a 7-point Likert scale indicating level of agreement. Likert response options either ranged from "Not at all important" to "Extremely important" or from "Strongly disagree" to "Strongly agree". To assess within-subject changes in these attitudes, participants completed the same attitude survey before and after playing the game.

3.4.2 Temple Presence Inventory, Engagement Subscale. Engagement is a critical aspect of the learning process [31], drastically influencing a learner's motivation to continue interacting with a system and the educational content [42]. To assess participant engagement with the *Academical* game, we utilized the Engagement subscale (Cronbach's alpha = 0.90) of the Temple Presence Inventory (TPI) [32]. The TPI is an instrument that has been validated for use with games [33] and measuring game engagement [36].

3.5 Statistics

All data was evaluated using Matlab and is presented in the text as mean ± standard deviation (SD). Within-subject comparisons were conducted using non-parametric two-sided Wilcoxon sign rank tests with a 95% confidence interval, and Cohen's d effect size strengths are described according to [13]. Because the data was ordinal, all inter-variable relationships were evaluated using non-parametric Spearman correlation methods (which is robust against outliers for large N), with correlation strengths described according to [14]. Therefore, the correlation coefficients reported in this paper indicate strength of a monotonically increasing relationship rather than linearity.

4 RESULTS

4.1 RCR Attitudes

In order to gauge whether playing *Academical* could improve participants' attitudes about RCR, we conducted within-subject comparisons of pre- and post-game attitude ratings. A series of Wilcoxon sign rank tests revealed that, after playing *Academical*, participants on average reported a significant improvement in agreement with every individual item in the attitudes survey (see Table 1; all $p<0.01$; effect size range of d = 0.35-0.57, which are small to medium). The average participant initially did not feel that RCR was personally important—the most common pre-game attitude score for item 1 was a neutral score of 4 (n = 25, 42%), with scores ranging from 1-7. After playing the game, only 13 participants (22%) reported a neutral score for this first item, with the most common post-game score being 6 (n = 20, 33%). These results for item 1 indicated that the participants felt that RCR was much more personally important after playing the game. Conversely, participants generally initially agreed with the importance of RCR for researchers—for items 2-6, most pre-game scores were positive (>4). Even though these scores were relatively high to begin with (compared to item 1), they still significantly improved after gameplay. The results for items 2-6 indicated that the participants also felt that RCR was much more important for researchers after playing the game. For each participant, we averaged the six attitude scores to find an overall attitude score for both test-points (pre: 5.3±0.9; post: 5.9±0.9; change: 0.55±0.7). Wilcoxon sign rank analysis also showed that participants' overall

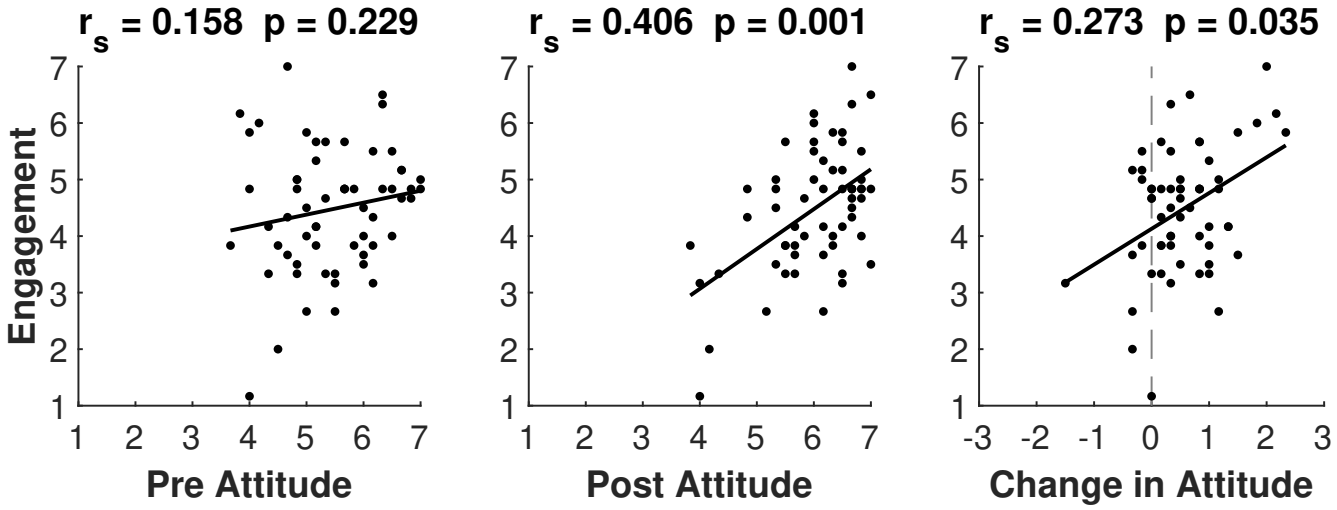

Figure 2: Participants' feelings of engagement while playing *Academical* were significantly correlated with post-game attitudes and a change in attitude, but not with pre-game attitudes. For simpler visual comparison with the overall attitude scores, engagement scores are reported here as the average (rather than the sum) of the six survey items. Non-parametric Spearman correlation coefficients are provided above each result.

attitude score increased significantly after playing the game (Rank sign test: r = 0.31, p < 0.001; effect size d = 0.65, which is medium). Overall, these results confirmed our first hypothesis and demonstrate that playing a short session of *Academical* can significantly improve a variety of important attitudes about RCR.

4.2 Engagement Correlations with RCR Attitudes

After playing the game, participants completed the Engagement subscale of the TPI Survey—a set of six questions validated for assessing feelings of engagement with an experience (i.e., playing a game). Participants on average reported an engagement score of 26.9±6.6 out of a possible 42 points (median: 28; range: 7-42). Over half the participants (n = 38, 63%) reported feeling at least moderately engaged (score >24, i.e., average survey item score >4). These results show that individual participants in this study varied greatly in their feelings of engagement while playing the game.

We expected that participants' reported engagement with the game would predict their post-game attitudes about RCR. First, Spearman correlations revealed that engagement did not predict participants' pre-game attitude scores (r_s = 0.16, p = 0.23). In contrast, we found that engagement was significantly correlated with post-game attitudes (r_s = 0.41, p = 0.001, moderate strength). Engagement was also correlated with participants' change in attitude (r_s = 0.27, p = 0.04, weak strength). Together, these results indicate that after playing *Academical*, participants changed their RCR attitudes to more closely align with their feelings of engagement with the game.

5 DISCUSSION

Our work evaluating *Academical* highlights the potential of choice-based interactive storytelling games for teaching the full breadth of distinct learning outcomes essential to RCR education. Specifically, prior research on interactive narrative games has demonstrated their efficacy in both engaging students and teaching conceptual knowledge [39] as well as moral reasoning skills [38]. This paper adds an important piece to further understand the potential of utilizing interactive narrative games to teach ethically complex topics by expanding upon these existing findings to illustrate that such games can also impact attitudes (paired t-test: r = 0.31, p<0.001, d = 0.65). Importantly, this collection of evidence—existing literature [38, 39] combined with the findings presented here—indicates that the choice-based interactive storytelling design of interactive narrative video games (such as *Academical*) can successfully train both cognitive and socio-affective learning outcomes. To the best of our knowledge, this is an achievement which has not yet been documented for existing web-based RCR pedagogy [45, 53]. It also serves to expand upon existing literature, suggesting that interactive narrative can effectively influence attitudes similar to what has been shown with traditional narrative [16, 57].

5.1 Implications for Design

5.1.1 The Caveats of Using Interactive Role-Play for Training Attitudes. Role-play provides an engaging opportunity to embody contending perspectives on an issue, making it one of the most promising discussion methods for improving comprehension and execution of ethical behavior [11]. While role-play has been shown to effectively train learning outcomes that drive improvements in behavior for topics involving ethical issues [46, 52, 54, 58, 62], role-play activities are not always effective for improving attitudes [47, 60]. Specifically, paired live-action role-play can leave students feeling awkward or distracted, affording opportunity for the exercise to be less valuable than more controlled forms of discussion learning (e.g., case studies) [53]. Our results highlight the

potential of utilizing choice-based interactive narrative games to deliver a self-paced, single-player activity that facilitates a comparatively more controlled form of ethical role-play. Presenting the role-play exercise using interactive narrative eliminates the possibility of an uncomfortable or unproductive interpersonal interaction, which should help reduce the chance that the player will develop negative feelings in association with the subject matter. Furthermore, players can take as much time as needed to fully understand the stories' dilemmas and various possible outcomes, which should assist learning. However, without direct engagement from a peer or educator, the single-player nature of an interactive narrative game also affords players the opportunity to avoid genuinely executing the learning exercise (e.g., advancing through a story without reading it), which is a known issue for existing online RCR training modules. Therefore, it is important for the designers of interactive narrative games to develop story content that facilitates players' genuine engagement (and subsequent learning) with the game.

5.1.2 The Importance of Engagement within Interactive Narrative Games. GBL research has demonstrated that engagement can influence a student's motivation to learn [12, 41] and can especially impact affective learning outcomes like attitudes [21, 35]. Compared to passive reading, the interactive narrative format requires a player to engage with the content in order to make choices that direct the story toward a particular conclusion—which is an enjoyable exercise for many people. However, care should be taken to generalize *Academical*'s success across the interactive narrative game genre. Our results highlight the importance of ensuring that an interactive narrative is engaging for the player, as post-game attitudes ($r_s = 0.41$, $p = 0.001$) and changes in attitudes from pre to post ($r_s = 0.27$, $p = 0.04$) were significantly correlated with participants' engagement. This indicates that after playing *Academical*, participants changed their RCR attitudes to more closely align with their feelings of engagement with the game, suggesting that a more engaging game experience was more likely to result in more positive feelings about RCR (and vice versa).

Clearly, merely using the interactive narrative medium does not guarantee that a story will feel immersive or engaging for all (or even any) readers. For instance, the results of the present study indicate that some participants did not feel particularly engaged with the game. This is a problem considering that engagement is a critical component helping to drive both cognitive and socio-affective learning outcomes. Therefore, it is crucial for designers of interactive narrative games to consider how aspects of their design impact engagement and employ various techniques to improve it. For instance, the relatability or lack thereof for their content (either characters or story) can cause players to disengage from the narrative [21], so utilizing a demographically diverse cast of characters or enabling the player to personalize their character images for the narrative could improve relatability and subsequently engagement. However, it is also important to consider that some people are simply less willing to exert mental effort, suggesting that they may not experience similar benefits from the increased engagement encouraged by the interactive narrative medium [22].

5.2 Study Limitations

One key disadvantage of this study is that it did not utilize a validated metric to gauge RCR attitudes, and so the relevance of the measured attitudes for informing/predicting ethical behavior is unknown. However, most of these survey items were taken from [28] and are therefore quite likely to be relevant to RCR education. Pre-post data from a control group (either untrained or trained by a traditional web-based RCR course) would help to further contextualize both major results of this study. Other useful control data could include distractor questions (i.e., pre-post assessment of attitudes unrelated to the training material).

6 CONCLUSION AND FUTURE WORK

This paper extends the breadth of evidence supporting the efficacy of interactive choice-based narrative games for training ethics—and more specifically scientists about how to conduct research responsibly. The results of this study support the hypothesis that playing a single brief session of *Academical*, a choice-based interactive narrative game, can significantly improve players' attitudes about RCR, thus extending the range of evidence illustrating the game's pedagogical efficacy for teaching every key RCR learning outcome (i.e., knowledge, moral reasoning skills and attitudes). The study also demonstrates a moderately significant relationship between engagement playing the game and post-game RCR attitudes, indicating that *Academical*'s advantage for engaging players is predictive of subsequent achievement for that socio-affective learning outcome. However, this relationship warrants further study to better understand its impact. These results further elucidate the value of a choice-based interactive storytelling game, such as *Academical*, for teaching RCR and provide implications for the use of interactive storytelling games to improve learning outcomes of ethically complex content such as RCR.

Future work with a longitudinal study should be conducted to examine long-term retention of learning outcomes as well as the effect of more training (e.g., playing through all nine scenarios or supplementing other existing RCR courses). Additionally, prior work has indicated that experienced researchers may have well-formed RCR attitudes and therefore be less likely to feel measurably different in response to training [44]. In order to determine the generalizability of the current results for all researchers, future work should investigate whether more senior scientists also experience similar attitude boosting effects after playing *Academical*. Future studies of *Academical* will also continue to explore more aspects of play that may explain the game's efficacy, particularly character relatability [9, 21]. Finally, it will also be important to understand whether being in a research community that fosters strong RCR values (e.g., through mentorship) can impact the game's efficacy [2, 18, 27].

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A APPENDIX

A.1 TPI Engagement Subscale Survey

(1) To what extent did you feel mentally immersed in the experience?
(2) How involving was the experience?
(3) How completely were your senses engaged?
(4) To what extent did you experience a sensation of reality?
(5) How relaxing or exciting was the experience?
(6) How engaging was the story/material?