Teaching Responsible Conduct of Research Through an Interactive Storytelling Game

Edward F. Melcer
University of California, Santa Cruz
Santa Cruz, CA 95064, USA
eddie.melcer@ucsc.edu

James Ryan
BBN Technologies
St. Louis Park, MN 55416, USA
jryan@bbn.com

Nick Junius
Max Kreminski
University of California, Santa Cruz
Santa Cruz, CA 95064, USA
njunius@ucsc.edu
mkremins@ucsc.edu

Dietrich Squinkifer
Independent Artist
Montreal, QC H3W 1R1, Canada
hey@squinky.me

Brent Hill
University of Utah
Salt Lake City, UT 84112
brent.hill@hsc.utah.edu

Noah Wardrip-Fruin
University of California, Santa Cruz
Santa Cruz, CA 95064, USA
nwf@soe.ucsc.edu

Abstract

Concepts utilizing applied ethics, such as responsible conduct of research (RCR), can prove difficult to teach due to the complexity of problems faced by researchers and the many underlying perspectives involved in such dilemmas. To address this issue, we created *Academical*, a choice-based interactive storytelling game for RCR education that enables players to experience a story from multiple perspectives. In this paper, we describe the design rationale of *Academical*, and present results from an initial pilot study comparing it with traditional web-based educational materials from an existing RCR course. The preliminary results highlight that utilizing a choice-based interactive story game may prove more effective for RCR education, with significantly higher engagement and comparable or better scores for tests of RCR topics.

Author Keywords

Choice-based; Role-playing; Interactive Storytelling; Narrative Game; Educational Game; RCR.

CCS Concepts

•**Human-centered computing** → **Human computer interaction (HCI);** User studies;

Introduction

Topics such as the responsible conduct of research (RCR) are difficult to teach due to the complexity of applied ethics and ethical decision-making [2], the need for moral reasoning [39], and the lack of existing educational tools that are motivating and foster critical thinking [12]. While past work has attempted to address these issues through alternative learning approaches such as group mentoring [48] and role-playing [3, 40], these issues have still remained largely unaddressed—resulting in ill-defined content, format, and goals, as well as minimal evidence for effectiveness [11]. Conversely, in the context of educational games, choice-based interactive storytelling is a popular format for narrative videogames [7, 38, 28], and this format has been shown to increase engagement/motivation as well as learning outcomes for rote STEM topics [35, 46, 49].

We hypothesized that the choice-based, role-playing nature of interactive storytelling games could also be employed to improve student engagement and learning outcomes within ethically complex topics (such as RCR education), which require learners to understand a variety of perspectives and perform ethical decision-making. As a result, we created *Academical*—a choice-based interactive storytelling game for RCR education that allows players to experience a story from multiple perspectives. In this paper, we discuss the design of *Academical*, and provide results from an initial pilot study comparing engagement and learning outcomes of our web-based game with traditional web-based educational materials from a RCR course at the University of Utah.

Background

Choice-based Interactive Storytelling

Though it is attested as far back as the sixteenth century [36, 27], choice-based interactive storytelling was made famous by the *Choose Your Own Adventure* book series [34, 37] and is now most prominent as a popular format for narrative videogames [7, 38, 28]. In this format, players navigate a *plot graph* [47] by making decisions (typically on behalf of a character) at branching points in the narrative (e.g., see Figure 2). Research in this area has typically concerned the history [7, 27, 38, 36], analysis [22, 28, 23], or generation [10, 24, 32] of works in the choice-based format.

Interactive Storytelling and Learning

Interactive storytelling has substantial potential for education and games [5, 45]. Specifically, narrative/storytelling is an important element that can be added to educational games in order to maintain and increase students' motivation [4, 6, 31, 35], with some suggesting that integration of a good story into an educational game will determine its success or failure [8]. Interactive storytelling has been incorporated into a number of educational games focusing on topics such as history [4, 42], STEM [5, 46, 49], and bullying [1, 44]. However, the majority of research on educational interactive storytelling games has focused on adaptivity [9, 16], interactivity [42, 49], emergent narrative [1], and the game creation process [4, 43]. As a result, there is surprisingly little work examining the impact of an interactive storytelling approach on learning outcomes (exceptions being [35, 44, 46, 49]), especially for topics with ethically complex concepts that require a variety of perspectives.

Responsible Conduct of Research

Although students generally know that they should report data honestly and cite sources accurately, they might not know specific standards or obligations of RCR—such as criteria for co-authorship and maintaining confidentiality of manuscripts reviewed for publication [40]. The importance of RCR is such that many major funding agencies, such as the National Institutes of Health (NIH) and National Science Foundation (NSF), explicitly require researchers
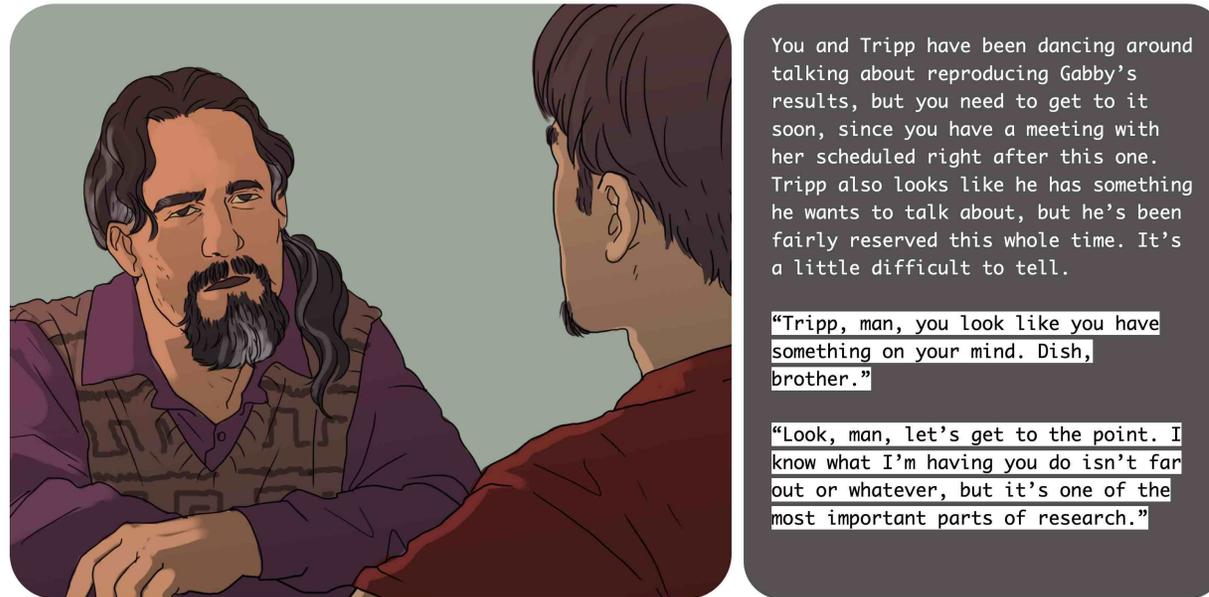
> You and Tripp have been dancing around talking about reproducing Gabby's results, but you need to get to it soon, since you have a meeting with her scheduled right after this one. Tripp also looks like he has something he wants to talk about, but he's been fairly reserved this whole time. It's a little difficult to tell.
>
> "Tripp, man, you look like you have something on your mind. Dish, brother."
>
> "Look, man, let's get to the point. I know what I'm having you do isn't far out or whatever, but it's one of the most important parts of research."

Figure 1: A choice point from *Academical*'s final scenario, "Fallen Angel Y2K." In this scene, the player controls a busy professor whose graduate student suspects that a postdoc in the lab has fabricated research results. The two highlighted text blocks represent dialogue options between which the player must select.

supported by their grants to receive RCR training [30, 33]. Currently, the NIH provides a guideline of nine core RCR topics: 1) *conflict of interest*, 2) *human and animal subjects*, 3) *mentoring*, 4) *collaboration*, 5) *peer review*, 6) *data management*, 7) *research misconduct*, 8) *authorship and publication*, and 9) *scientists and society* [13]. Past research on RCR education has ranged from issues teaching ethical theories underlying RCR [2] and identifying metacognitive reasoning strategies that facilitate ethical decision-making [17] to the use of group mentoring [48] and role-playing [3, 40] for improved efficacy. However, there is still

a notable engagement issue within current RCR education, and a critical need for a variety of tools to improve discussion, engagement, and critical thinking [12]. As a result, an interactive storytelling approach may prove effective for increasing motivation and fostering deeper critical thinking.

Design of *Academical*

Academical is a work of choice-based interactive storytelling [22, 23, 18] that was developed using the Twine authoring framework [7, 38]. Figure 1 shows a screenshot taken during gameplay, which occurs in a web browser. The
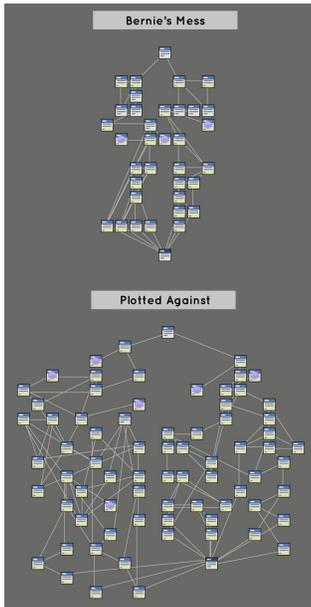
Figure 2: Plot graphs for two of *Academical*'s playable scenarios, visualized in the Twine authoring environment. Each node in these graphs is a Twine "passage" (story unit), some of which are player choice points that link to other passages. As the game progresses, the scenarios become more complex—of the two scenarios shown here, the bottom one comes later in the game.

game comprises nine playable scenarios, each pertaining to a specific issue in RCR [13]. These scenarios are adapted (with permission) from a series of existing educational RCR role-playing prompts [3, 40].

Each playable scenario in *Academical* centers on a conversation between two stakeholders in the RCR issue at hand, one of whom is controlled by the player—in the sense that they select dialogue options for that character. By virtue of these choices, the player will ultimately reach one of several possible endings, a subset of which represent successful navigations of the situation. Upon reaching a good ending for one character, the player unlocks the other interlocutor and may replay the scenario from that person's viewpoint. In turn, reaching a good ending for the second character in a given scenario unlocks the next scenario, and the game concludes upon completion of the final scenario. Generally, the scenarios become more complex (and difficult to navigate) as the game proceeds, as Figure 2 illustrates.

At the outset of the project, it was decided that the format of choice-based interactive storytelling—which allows a player to experience a story from multiple perspectives, and to replay scenes to see how different actions play out—would demonstrate the complicated nature of RCR to students in a compelling way. In adapting the role-playing prompts, we sought to show how seemingly obvious answers around questions of research ethics can be complicated by factors such as power dynamics and marginalized identities and experiences. Instead of cleanly delineating right and wrong answers, *Academical* showcases complexity and uncertainty to provoke questions around how courses of action could have unexpected consequences. In turn, while all successful paths through the game's scenarios represent the player character acting responsibly, not all of the situations reach clear resolutions. Specifically, many scenarios

feature paths that appear to represent obvious solutions, but ultimately lead to bad outcomes. Through replaying and selecting new options, the player explores the social concerns encompassing a given RCR scenario, which may lead to a richer understanding of the ethical complications that one can encounter while conducting research.

Pilot Study

RCR is a complicated topic to teach that requires understanding a variety of perspectives and dilemmas that impact research ethics [14, 41]. As a result, we wanted to evaluate whether a choice-based interactive storytelling design, such as the one employed in *Academical*, could prove more effective than traditional approaches for teaching ethically complex topics. We hypothesized that the choice-based, role-playing nature of *Academical*—which is specifically designed to highlight how research ethics can be complicated by many factors such as power dynamics and marginalized identities—would be 1) more engaging and 2) as effective as traditional RCR educational materials. In order to explore these hypotheses, we conducted a between-subjects pilot study comparing our choice-based interactive storytelling game approach with existing web-based educational materials from an RCR course at the University of Utah. The pilot study consisted of two conditions: 1) a group that read through two modules of the web-based educational RCR materials covering peer review and authorship; and 2) a group that played two chapters/levels of *Academical* covering peer review and authorship content.

Procedure
Participants were told that the study was to explore different approaches to RCR education, and that they would either play a game or read materials teaching selected RCR concepts. They then completed an online survey collecting demographic information (age, prior gaming experience,

RCR Peer Review Questions

1. "According to the study materials, peer reviewers are asked to make judgements about the quality of a proposed or completed project. This certainly includes all EXCEPT the following:"
(Multiple Choice)

2. "If you can figure out the authors of a paper you are peer reviewing after conflicts of interest are disclosed, should you still review the paper?"
(Yes/No)

3. "There is no simple solution to the problem of bias in peer review. However, researchers can lessen the impact of bias by writing transparent reviews."
(True/False)

Table 1: The post-test RCR peer review quiz questions. Questions were taken from an existing RCR course at the University of Utah.

prior RCR experience, and so forth). Upon completing the survey, participants were randomly assigned to one of the two conditions (web materials or *Academical*). After completing the RCR training for peer review and authorship, participants were then asked to complete a post-test that assessed their engagement with the training material and knowledge of peer review and authorship RCR concepts.

Participants
A convenience sample of 28 university graduate and undergraduate students—the target populations for RCR training—were recruited for the study (age: μ=24.8, σ=7.6). There were 10 female, 14 male, and 3 non-binary participants, with 1 declining to disclose gender. During the study, participants were randomly assigned to one of the two conditions: web materials (**14 total**; 3 female, 2 non-binary, 8 male, 1 decline to answer) and *Academical* game (**14 total**; 7 female, 1 non-binary, 6 male). None of the participants reported prior RCR training within the past 2 years.

Measures
Temple Presence Inventory, Engagement Subscale
Engagement is an critical aspect of the learning process [15], drastically influencing a learner's motivation to continue interacting with a system and the educational content [29]. In order to assess participant engagement with the two educational RCR tools employed, we utilized the Engagement subscale of the Temple Presence Inventory (TPI) [19]. The TPI is an instrument that has been validated for use with games [20], and measuring game engagement [21].

Peer Review and Authorship RCR Quizzes
To assess and compare how effective the two RCR tools were for teaching peer review and authorship concepts, we utilized two quizzes from an existing online RCR course at the University of Utah. Each quiz consists of three questions around a respective topic, and each question is either

Post-Test Results

Measures	Web		Game		Sig	ES
	μ	σ	μ	σ	p	r
TPI Engagement	23.4	9	30.1	6.1	**.029**	**.4**
Peer Review Test	2.14	0.77	2.93	0.27	**.001**	**.56**
Authorship Test	2.36	0.75	2	0.79	.23	N/A

Table 2: Post-test results for the TPI Engagement subscale, Peer Review test, and Authorship test. The table contains mean scores, standard deviations, t-test scores for significance, and effect size—which is medium to large for significant differences.

true/false, yes/no, or multiple choice (see Tables 1 and 3).

Results
Prior Knowledge and Experience
According to a series of independent samples t-tests, participants in the two conditions did not differ with respect to age, prior game experience, or prior interactive story experience (all p values >= .12). Similarly, no participants reported prior RCR training in the past 2 years. Therefore, we can assume that participants in both groups had similar prior RCR, game, and interactive story experience.

Engagement with RCR Training Tools
We first examine participant engagement between the different RCR educational tools. In order to analyze differences between the web materials and *Academical* game conditions, we used an independent samples t-test. The first row of Table 2 shows descriptive statistics for scores on the TPI Engagement subscale, as well as significant differences and effect sizes. Results found a significant difference in favor of *Academical* increasing participant engagement (p = .029, r = .4), suggesting that a choice-based

RCR Authorship Questions

1. "When should authorship for a paper be discussed?"
(Multiple Choice)

2. "Which of the following is NOT considered a contribution to a paper?"
(Multiple Choice)

3. "There is disagreement over whether authorship should be limited to individuals who contributed to all phases of a publication or whether individuals who made more limited contributions deserve authorship credit."
(True/False)

Table 3: The post-test RCR authorship quiz questions. Questions were taken from an existing RCR course at the University of Utah.

interactive story game is a more engaging experience for RCR training than traditional web reading materials.

RCR Learning Outcomes
To better understand participants' learning outcomes, we analyzed post-test scores on the RCR peer review and authorship quizzes. Descriptive statistics, statistical significance, and effect sizes for the two measures are shown in the bottom two rows of Table 2. A series of independent samples t-tests showed that participants in the *Academical* condition scored significantly higher on the peer review test (p = .001, r = .56) and comparable to the web materials for the authorship test, with no statistically significant difference between scores (p = .23). This suggests that, in terms of short-term learning, a choice-based interactive story approach can be more effective or comparable to traditional educational RCR materials for certain RCR topics.

Discussion
Results from our pilot study highlight the potential of choice-based interactive storytelling games for improving student engagement and learning outcomes within RCR education.

First, the independent samples t-test for the TPI Engagement subscale showed that *Academical* was significantly more engaging than traditional web-based RCR educational materials (p=.029, r=.4). This confirmed our first hypothesis, and also falls in line with existing claims [4, 6, 16, 31, 42] and findings [35, 44, 49] that interactive storytelling designs can improve learner engagement and motivation. Additionally, we further extend these findings to illustrate that interactive storytelling games can also increase motivation when learning more ethically complex topics—beyond the current rote STEM [35, 49] and history [4] examples.

Second, we found that short term learning outcomes for RCR education were comparable (authorship; p=.23) or

significantly better for *Academical* (peer review; p=.001, r=.56). This serves to extend current findings on the learning outcomes of educational interactive storytelling games [35, 44, 46, 49] by providing evidence for the efficacy of such games in teaching concepts that require ethical decision-making and multiple perspectives. Furthermore, given that a choice-based interactive storytelling design approach is both more engaging than traditional RCR materials and equally/more effective for learning outcomes, *Academical* is ultimately a useful tool to address the engagement and critical thinking needs of current RCR education [12].

Conclusion, Limitations, and Future Work
In this paper we described the design of *Academical*, a choice-based interactive storytelling game for RCR education that enables players to experience a story from multiple perspectives. We also presented results from an initial pilot study comparing *Academical* with traditional web-based RCR educational materials. The pilot study results highlighted that a choice-based interactive story game design may prove to be an effective RCR education tool, with significantly higher engagement and comparable or better scores for tests of RCR topics. However, the sample size is notably small for sufficiently evaluating the efficacy of an educational game [25]. Therefore, future work will need to further validate these results with a larger sample size to fully prove the hypotheses, e.g., [26]. A longitudinal study also needs to be done to examine long term learning outcomes and improvements to RCR practices over time. Furthermore, prior work has demonstrated that traditional education approaches may increase students' RCR knowledge, but not their moral reasoning [39]. Given that *Academical* enables a more direct exploration of ethics-based decisions, future work should also explore if a choice-based interactive story design can have a more substantial impact on learners' moral reasoning.

REFERENCES

[1] Ruth S Aylett, Sandy Louchart, Joao Dias, Ana Paiva, and Marco Vala. 2005. FearNot!–an experiment in emergent narrative. In *International Workshop on Intelligent Virtual Agents*. Springer, 305–316.

[2] Mathieu Bouville. 2008. On using ethical theories to teach engineering ethics. *Science and Engineering Ethics* 14, 1 (2008), 111–120.

[3] Bradley J Brummel, CK Gunsalus, Kerri L Anderson, and Michael C Loui. 2010. Development of role-play scenarios for teaching responsible conduct of research. *Science and Engineering Ethics* 16, 3 (2010), 573–589.

[4] Dimitrios Christopoulos, Pavlos Mavridis, Anthousis Andreadis, and John N Karigiannis. 2011. Using Virtual Environments to Tell the Story:" The Battle of Thermopylae". In *2011 Third International Conference on Games and Virtual Worlds for Serious Applications*. IEEE, 84–91.

[5] Polina Danilicheva, Stanislav Klimenko, Yury Baturin, and Alexander Serebrov. 2009. Education in virtual worlds: Virtual storytelling. In *2009 International Conference on CyberWorlds*. IEEE, 333–338.

[6] Michele D Dickey. 2006. Game design narrative for learning: Appropriating adventure game design narrative devices and techniques for the design of interactive learning environments. *Educational Technology Research and Development* 54, 3 (2006), 245–263.

[7] Jane Friedhoff. 2013. Untangling Twine: A Platform Study. In *Proc. DiGRA*.

[8] Stefan Göbel, André de Carvalho Rodrigues, Florian Mehm, and Ralf Steinmetz. 2009. Narrative game-based learning objects for story-based digital educational games. *narrative* 14 (2009), 16.

[9] Stefan Göbel and Florian Mehm. 2013. Personalized, adaptive digital educational games using narrative game-based learning objects. In *Serious Games and Virtual Worlds in Education, Professional Development, and Healthcare*. IGI Global, 74–84.

[10] Matthew Guzdial, Brent Harrison, Boyang Li, and Mark Riedl. 2015. Crowdsourcing Open Interactive Narrative.. In *Proc. Foundations of Digital Games*.

[11] Michael Kalichman. 2013. A brief history of RCR education. *Accountability in research* 20, 5-6 (2013), 380–394.

[12] Michael Kalichman. 2014. Rescuing responsible conduct of research (RCR) education. *Accountability in research* 21, 1 (2014), 68–83.

[13] Michael Kalichman. 2016. Responsible Conduct of Research Education (What, Why, and Does It Work?). *Academic medicine: journal of the Association of American Medical Colleges* 91, 12 (2016), e10.

[14] Michael W Kalichman and Dena K Plemmons. 2007. Reported goals for responsible conduct of research courses. *Academic Medicine* 82, 9 (2007), 846–852.

[15] Greg Kearsley and Ben Shneiderman. 1998. Engagement theory: A framework for technology-based teaching and learning. *Educational technology* 38, 5 (1998), 20–23.

[16] Michael D Kickmeier-Rust, Stefan Göbel, and Dietrich Albert. 2008. 80Days: Melding adaptive educational technology and adaptive and interactive storytelling in digital educational games. In *Proceedings of the First International Workshop on Story-Telling and Educational Games (STEG'08)*. 8.

[17] Vykinta Kligyte, Richard T Marcy, Sydney T Sevier, Elaine S Godfrey, and Michael D Mumford. 2008. A qualitative approach to responsible conduct of research (RCR) training development: Identification of metacognitive strategies. *Science and Engineering Ethics* 14, 1 (2008), 3–31.

[18] Hartmut Koenitz, Gabriele Ferri, Mads Haahr, Diğdem Sezen, and Tonguç İbrahim Sezen. 2015. *Interactive digital narrative: history, theory and practice*. Routledge.

[19] Matthew Lombard, Theresa B Ditton, and Lisa Weinstein. 2009. Measuring presence: the temple presence inventory. In *Proceedings of the 12th Annual International Workshop on Presence*. 1–15.

[20] Matthew Lombard, Lisa Weinstein, and Theresa Ditton. 2011. Measuring telepresence: The validity of the Temple Presence Inventory (TPI) in a gaming context. In *ISPR 2011: The International Society for Presence Research Annual Conference*. Edinburgh.

[21] Rosa Mikeal Martey, Kate Kenski, James Folkestad, Laurie Feldman, Elana Gordis, Adrienne Shaw, Jennifer Stromer-Galley, Ben Clegg, Hui Zhang, Nissim Kaufman, and others. 2014. Measuring game engagement: multiple methods and construct complexity. *Simulation & Gaming* 45, 4-5 (2014), 528–547.

[22] Peter Mawhorter, Michael Mateas, Noah Wardrip-Fruin, and Arnav Jhala. 2014. Towards a theory of choice poetics. In *Proc. Foundations of Digital Games*.

[23] Peter Mawhorter, Carmen Zegura, Alex Gray, Arnav Jhala, Michael Mateas, and Noah Wardrip-Fruin. 2018. Choice poetics by example. In *Arts*, Vol. 7. Multidisciplinary Digital Publishing Institute, 47.

[24] Peter Andrew Mawhorter. 2016. *Artificial intelligence as a tool for understanding narrative choices*. Ph.D. Dissertation. UC Santa Cruz.

[25] Edward F Melcer, Victoria Hollis, and Katherine Isbister. 2017. Tangibles vs. mouse in educational programming games: Influences on enjoyment and self-beliefs. In *Proceedings of the 2017 CHI conference extended abstracts on human factors in computing systems*. 1901–1908.

[26] Edward F Melcer and Katherine Isbister. 2018. Bots & (Main) frames: exploring the impact of tangible blocks and collaborative play in an educational programming game. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. 1–14.

[27] Brian Moriarty. 2015. I Sing the Story Electric. PRACTICE. (2015). `http://ludix.com/moriarty/electric.html` Accessed Jan 2 2020.

[28] John Thomas Murray. 2018. *Telltale Hearts: Encoding Cinematic Choice-based Adventure Games*. Ph.D. Dissertation. UC Santa Cruz.

[29] Heather L O'Brien and Elaine G Toms. 2008. What is user engagement? A conceptual framework for defining user engagement with technology. *Journal of the American society for Information Science and Technology* 59, 6 (2008), 938–955.

[30] National Institutes of Health and others. 1992. Reminder and update: requirement for instruction in the responsible conduct of research in national research service award institutional training grants. *NIH Guide for Grants and Contracts* 21, 43 (1992).

[31] Natalia Padilla-Zea, Francisco L Gutiérrez, José Rafael López-Arcos, Ana Abad-Arranz, and Patricia Paderewski. 2014. Modeling storytelling to be used in educational video games. *Computers in Human Behavior* 31 (2014), 461–474.

[32] Nathan Partlan, Elin Carstensdottir, Erica Kleinman, Sam Snodgrass, Casper Harteveld, Gillian Smith, Camillia Matuk, Steven C Sutherland, and Magy Seif El-Nasr. 2019. Evaluation of an automatically-constructed graph-based representation for interactive narrative. In *Proc. Foundations of Digital Games*. ACM.

[33] SH Plimpton. 2009. NSF's Implementation of Section 7009 of the America COMPETES Act. *Fed. Regist* 74, 160 (2009), 42126–42128.

[34] Jake Rossen. 2014. A Brief History of "Choose Your Own Adventure". *Mental Floss* (Apr. 10 2014).

[35] Jonathan P Rowe, Lucy R Shores, Bradford W Mott, and James C Lester. 2011. Integrating learning, problem solving, and engagement in narrative-centered learning environments. *International Journal of Artificial Intelligence in Education* 21, 1-2 (2011), 115–133.

[36] James Ryan. In press. A Garden, A Forking Path: Interactive Branching Narrative in *The Lady of May* (1578). In *Proc. 1st Workshop on the History of Expressive Systems*.

[37] Anastasia Salter. 2014. *What is your quest?: from adventure games to interactive books*. University of Iowa Press.

[38] Anastasia Salter. 2016. Playing at empathy: Representing and experiencing emotional growth through Twine games. In *Proc. International Conference on Serious Games and Applications for Health*. IEEE, 1–8.

[39] Karen B Schmaling and Arthur W Blume. 2009. Ethics instruction increases graduate students' responsible conduct of research knowledge but not moral reasoning. *Accountability in Research* 16, 5 (2009), 268–283.

[40] Stephanie N Seiler, Bradley J Brummel, Kerri L Anderson, Kyoung Jin Kim, Serena Wee, CK Gunsalus, and Michael C Loui. 2011. Outcomes assessment of role-play scenarios for teaching responsible conduct of research. *Accountability in Research* 18, 4 (2011), 217–246.

[41] Adil E Shamoo and David B Resnik. 2009. *Responsible conduct of research*. Oxford University Press.

[42] Qiulian Song, Ling He, and Xiaoqiang Hu. 2012. To improve the interactivity of the history educational games with digital interactive storytelling. *Physics Procedia* 33 (2012), 1798–1802.

[43] Ulrike Spierling. 2008. 'Killer Phrases': Design Steps for a Game with Digital Role-Playing Agents. In *Transactions on edutainment I*. Springer, 150–161.

[44] Scott Watson, Natalie Vannini, Megan Davis, Sarah Woods, Marc Hall, Lynne Hall, and Kerstin Dautenhahn. 2007. FearNot! an anti-bullying intervention: Evaluation of an interactive virtual learning environment. *Artificial Intelligence and Simulation of Behaviour (AISB), April* 24 (2007).

[45] Sebastian A Weiß and Wolfgang Müller. 2008. The potential of interactive digital storytelling for the creation of educational computer games. In *International Conference on Technologies for E-Learning and Digital Entertainment*. Springer, 475–486.

[46] Jui-Feng Weng, Hsiu-lien Kuo, and Shian-Shyong Tseng. 2011. Interactive storytelling for elementary school nature science education. In *2011 IEEE 11th International Conference on Advanced Learning Technologies*. IEEE, 336–338.

[47] Peter Weyhrauch. 1997. *Guiding Interactive Fiction*. Ph.D. Dissertation. Carnegie Mellon University.

[48] Caroline Whitebeck. 2001. Group mentoring to foster the responsible conduct of research. *Science and Engineering Ethics* 7, 4 (2001), 541–558.

[49] Lei Zhang, Doug A Bowman, and Caroline N Jones. 2019. Exploring Effects of Interactivity on Learning with Interactive Storytelling in Immersive Virtual Reality. In *2019 11th International Conference on Virtual Worlds and Games for Serious Applications (VS-Games)*. IEEE, 1–8.