Research Ethics Education in the STEM Disciplines:

The Promises and Challenges of a Gaming Approach

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Abstract

While education in ethics and the responsible conduct of research (RCR) is widely acknowledged as an essential component of graduate education, particularly in the STEM disciplines (science, technology, engineering, and math), little consensus exists on how best to accomplish this goal. Recent years have witnessed a turn toward the use of games in this context. Drawing from two NSF-funded grants (one completed and one on-going), this paper takes a critical look at the use of games in ethics and RCR education. It does so by: (a) setting the development of research and engineering ethics games in wider historical and theoretical contexts, which highlights their promise to solve important pedagogical problems; (b) reporting on some initial results from our own efforts to develop a game; and (c) reflecting on the challenges that arise in using games for ethics education. In our discussion of the challenges, we draw out lessons to improve this nascent approach to ethics education in the STEM disciplines.

Keywords

Responsible Conduct of Research; Research Ethics Education; Games; Pedagogy

1. Introduction

Ethics education for STEM (science, technology, engineering, and math) researchers entails ‘procedural,’ ‘intrinsic,’ and ‘extrinsic’ aspects of ethics (Schienke et al., 2009; Schieke et al., 2010; Tuana, 2010). Procedural ethics deal with issues that fall within the purview of traditional approaches to what is known in the U.S. as the responsible conduct of research (RCR): falsification, fabrication, and plagiarism; care for subjects (human and non-human animal); responsible authorship issues; peer review; handling of data; and conflicts of interests (see Steneck 2004). In Europe, these issues are often grouped under the term good scientific practice (GSP). Intrinsic ethics concern values that are embedded in the production of scientific or engineering research (for example, the choice of research questions, methods, materials, or equipment). Extrinsic ethics involve issues that are external to scientific practice, including issues of the relation between science and society (often called “broader impacts”), policy for science, and the use of science in policy making.

There is widespread agreement that graduate students in the STEM disciplines should receive training in these various dimensions of ethics. Indeed, it is now widely held that STEM students should learn to conceive of their fields as *intrinsically* ethical, such that making ethical decisions is part of their professional identity. Yet despite its importance, there is no consensus on how best to incorporate ethics into STEM education. Teaching venues range widely from online tutorials to classroom modules. Teaching methods also vary from text book-based delivery of important content to the use of case studies and scenario-based discussions.

In 2009, a National Academies Keck Center workshop took stock of what had been learned up to that point about ethics education for STEM students (Hollander 2009). The participants identified core ethical skills that ethics education should foster:

- Recognizing and defining ethical issues.
- Identifying relevant stakeholders and socio-technical systems.
- Collecting relevant data about the stakeholders and systems.
- Understanding relevant stakeholder perspectives.
- Identifying value conflicts.
- Constructing viable alternative courses of action or solutions and identifying constraints.
- Assessing alternatives in terms of consequences, public defensibility, institutional barriers, etc.
- Engaging in reasoned dialogue or negotiations.
- Revising options, plans, or actions (Hollander 2009, p. 13).

Yet, the workshop participants concluded that the ethics teaching approaches used up to then had not been adequate to cultivate these skills. They found that although students may learn something about ethical theory from course material and instruction, what they learn does not translate well into everyday practice. Even if ethics education has some positive results in the short-term, pressures to publish and perform can overwhelm students and early-career researchers and undermine those results. Workshop participants tended to agree "that assessments of ethics instruction and mentoring were at an early stage of development" and that it is difficult to tell "if the right things are being measured or whether students can call on what they've learned afterwards, when needed" (Hollander 2009, p. 33). As several participants at the workshop noted, the importance of research ethics did not really sink in until they actually confronted real dilemmas in their professional lives.

This observation regarding the lack of connection between ethical theory and scientific practice suggests that approaches to ethics education that immerse students in life-like situations may be an improvement over traditional content-delivery methods. Immersion is arguably the strength of games: by plunging students into situations in which they must practice making decisions, games can make ethics education more impactful and effective. This hypothesis drives our research project and provides the context for this paper.

In this paper, we first set the development of ethics games into wider historical and theoretical contexts. Next, we report on some of our efforts to develop an ethics game. Then, we outline three key challenges involved in designing effective ethics games and offer some lessons learned in hopes of improving future efforts to develop ethics games for STEM students.

2. Ethics Games in Context: A Promising New Development?

In this section, we first briefly survey the historical development of ethics education in the STEM disciplines, culminating in the recent emergence of pedagogical ethics games. The point is not to offer a complete history of ethics – a task that would far exceed the scope of this paper – but rather to offer some sort of rationale for the rise of games and highlight some of the most promising aspects of games as instruments of ethics pedagogy.

2.1 Historical Development of Ethics Education in the STEM Disciplines

Three historical trends in the post-World War II era have contributed to the contemporary emphasis on ethics and RCR education in the STEM disciplines. First, many of the initial concerns about research practice focused on the use of human and non-human animals. Ethical reflection on non-human animals used in research dates back to the 19th century (see Briggle and Mitcham 2012). The use of human subjects in research first received intense international attention with the trial of Nazi physicians and the drafting of the 1946 Nuremberg Code, which has since been followed by additional ethical codes, including the World Medical Association's Declaration of Helsinki. In the U.S., the 1972 revelation of the Tuskegee Syphilis Study was a watershed moment in developing guidelines to protect the rights of human subjects of research, especially the 1978 *Belmont Report*.

The second trend was a rash of scientific misconduct cases exposed throughout the 1970s and 1980s (see Broad and Wade 1982; CORI 1995). This raised serious concerns within and beyond the scientific community. Within the scientific community, it became clear that professional standards of conduct and ethical values were not clearly articulated or widely understood. Outside of the scientific community, the U.S. Congress began to demand better oversight of research and established the Office of Research Integrity (ORI) in the Department of Health and Human Services.

The third trend is growing concern about how an increasingly powerful research enterprise impacts the social and natural worlds. The use of the atomic bomb first seriously posed questions about the social responsibilities of scientists and engineers for the consequences of their work. Rachel Carson's 1962 *Silent Spring* called attention to the unintended consequences of industrial and chemical research. The 1975 Asilomar conference similarly raised concerns about the potential hazards of genetic engineering, and the 1986 *Challenger* explosion initiated serious ethical reflection within the engineering community. The 1990 Human Genome Project implemented a formal program of ethical, legal, and social implications (ELSI) research. Since then, the wider ethical and social dimensions of science and technology – across the board from synthetic biology to geoengineering to nanotechnology and more – have continued to spark debate and institutional reform.

Accordingly, a growing emphasis on including ethics in the formal education of STEM students has emerged. In 1985, the Accreditation Board for Engineering and Technology (ABET, Inc.) required engineering programs to include ethics education in their curricula. In 1989, the U.S. National Institutes of Health (NIH) developed requirements that all institutions applying for NIH funds implement formal training in RCR for graduate students and postdoctoral researchers (NIH 1989). In 2009, the U.S. National Science Foundation (NSF) implemented a requirement for RCR training (NSF 2009). Similar developments have occurred in other countries (see Rhoades and Górski 2000). For example, the German report *Proposals for Safeguarding Good Scientific Practice* calls for more ethics education for STEM students (DFG 1998 (updated 2013)).

Most requirements for ethics education and RCR training do not specify how ethics should be taught and integrated into the STEM curriculum (see Steneck and Bulger 2007). Consequently, varied formats have been used, including short online tutorials, special modules of course curricula, seminars, workshops, and one-on-one interactions between students and mentors (Swazey and Bird 1997). These formats, in turn, employ a range of pedagogical tools from traditional forms of content-delivery to case-based or scenario-based discussions to, most recently, pedagogical games. Additionally, a variety of goals of research ethics education have been identified, including: knowledge of professional standards, awareness of the ethical dimensions of the STEM disciplines, and experience making and defending decisions about ethical issues (see Bird and Briggle 2005).

This diversity of approaches fuels the ongoing debate about the best ways to design and implement an effective ethics curriculum for STEM students. Indeed, one of the hottest topics in research ethics education is whether and how it might be possible to measure the effectiveness of various approaches (Kalichman 2009; Mumford et al. 2008). Regardless, most researchers agree that any effective program must possess a number of key characteristics (Bird 1999; IOM and NRC 2002). Among the most important characteristic is *interactivity*, which is a basic principle of learning science (Bransford, Brown, and Cocking 1999). Ethics education must integrate ways for students, while interacting with their peers, to engage with challenging questions. This trains the core ethical competencies of seeing complex issues from multiple perspectives and expressing and defending reasoned arguments. Ideally, the educational experience makes the ethical issues ‘real’ for students, a point that drives us into the theoretical dimensions of teaching ethics and that highlights what is potentially most promising about games.

2.2 Theoretical Dimensions of Ethics Education and Pedagogical Games

Many contemporary approaches to ethics education focus mainly on imparting knowledge of rules, principles, or methods. . But conveying such content, though important, does not exhaust the task of ethics education. The human condition presents novel situations fraught with ambiguities, uncertainties, and multiple perspectives.
Thinking through such situations requires context-sensitive reasoning. As a recent National Research Council report puts the point, good judgment is the most important “mechanism” for ethical decision making (NRC 2014). This is why many argue for a return to virtue ethics and its emphasis on practical moral reasoning (Anscombe 1958; Toulmin 1982; Annas 2002). Virtue theorists argue that leading an ethical life requires practicing and perfecting skills (acquiring habits, or virtues), both the intellectual skills of discerning the right action in a novel context and moral skills, such as the courage to act rightly despite pressures to conform or look the other way.

The centrality of virtue theory for contemporary STEM researchers was first made apparent in the health sciences. In his landmark 1966 essay “Ethics and Clinical Research,” anesthesiologist Henry Beecher described twenty-two cases of unethical experimentation involving human subjects. He noted that the then new concept of clinical research “can lead to unfortunate separation between the interests of science and the interests of the patient” (Beecher 1966, p. 368). Even at this early point in clinical research, codes and rules existed that were designed to ensure the informed consent of research subjects. Beecher also noted, “nearly everyone agrees that ethical violations do occur” (Beecher 1966, p. 368).

If codes and a shared moral understanding are in place, why, then, do violations persist? The answer is two-fold. First, codes and rules can never do more than provide general, abstract guidelines. In specific contexts it is always up to individual researchers to figure out which rules apply in which situations and how they are to be interpreted. In any complex human endeavor, rules are no substitute for human judgment: doing the right thing is rarely as simple as memorizing rules. This shows the importance of developing the intellectual-moral skills of discerning how ethical ideals are best realized in any given situation. Second, medical researchers face enormous temptations and pressures: temptations to profit and to find cures even at great costs and pressures to publish, get funded, and make discoveries. In such circumstances, it takes moral courage to do the right thing. In short, scientists must possess both intellectual and moral virtues if science is to be conducted responsibly.

This is why Beecher concluded that, although rules and codes are vital, “a far more important safeguard than consent is the presence of a truly *responsible* investigator” (Beecher 1966, p. 368). Individual scientists, he claimed, must be “intelligent, informed, conscientious, compassionate, [and] responsible” (Beecher 1966, p. 372). The responsible conduct of research requires scientists and engineers to possess these virtues. It is more than delivering a pre-defined bundle of content in the form of principles, codes, or formulas.

An emerging literature suggests that games can be effective pedagogical tools, because they provide the immersive and interactive experiences essential for developing skills or virtues (Prensky 2003; Barab et al. 2009; Briggle 2012; Sadowski et al., 2012; Briggle and Holbrook 2015). Indeed, the connection between games and education is deeply-rooted: humans, like many animals, learn vital life lessons through play. In *The Republic*, Plato states, “No compulsory learning can remain in the soul. In teaching children, train them by a kind of game, and you will be able to see more clearly the natural bent of each” (Book VII).

James Paul Gee (2003) argues that games not only can be used to deliver instructional content, but also, and more importantly, their architecture and the experience of gaming actually foster the cognitive skills necessary for improved learning. Similarly, the final report from the Summit on Educational Games (Federation of American Scientists, 2006) concluded that educational games may be effective in developing higher-order skills such as problem solving and decision-making. Additionally, game playing is nearly universal among college-aged students and often facilitates social discussions about civic and political life (Lenhart, Arafeh, & Macgill, 2008; Jones, Warren, & Lin, 2011).

For ethics education, games can immerse students in situations that force them to practice judgment, active listening, courage, and other skills or habits of character that are essential to being a responsible member of the STEM community. Games recast ethics education as less a matter of memorizing rules through content delivery systems (such as online RCR tutorials) and more a matter of practicing virtuous behavior in life-like environments that simulate the incentives, pressures, and other aspects of the decision contexts faced by scientists and engineers in the real world.

Games are akin to the case-study and scenario-based approaches to ethics and RCR education in that they ground ethical inquiry in the details of a particular scenario (Barrows 1986). But they go beyond case studies by putting students in the center of the action, giving them a stake in the activities, compelling them to make their own decisions in open-ended situations, and creating interpersonal dynamics of competition and cooperation (Sadowski et al. 2012). The interactivity of games, their potential for encouraging students to take risks, and their ability to tap into deeper levels of cognition, emotion, and reflection have all been advanced as reasons to further develop applied ethics games (McDaniel and Fiore 2010).

3. An Example of an Ethics Game for STEM Graduate Students

As part of an NSF EAGER grant (title and number omitted for anonymous review), we developed and piloted a research ethics game called “Grants & Researchers” to test the hypothesis that ethics games can improve ethical decision making by developing the virtues (skills) of STEM students. We are currently building on this research to develop and test two additional games through an NSF EESE grant (title and number omitted for anonymous review). Our research also follows another NSF EESE grant conducted by (names and institution) titled “Gaming Against Plagiarism” (GAP).

“Grants & Researchers” is a card game for 3-5 players designed to simulate the experience of ethical decision making within the context of academic research. To facilitate gameplay at multiple institutions, we produced a roughly eight-minute YouTube video that outlines the rules of the game while showing a game being played by students (http://youtu.be/L4Jk84HlLN8). Each player assumes the role of a researcher who submits grant proposals and manages the fulfillment of ongoing grants while having opportunities to collaborate with other researchers and challenge the integrity of other researchers’ grant work. As the researchers further their careers towards game victory, they face many situations where they must decide whether to make the most ethical decision or to cut corners in a manner they may regret later.

The game contains 2 card decks and several sets of colored chips. The first deck contains research cards of different types (Arts, Humanities, Sciences, and wildcards). The second deck contains cards representing grant opportunities and special world events. Each player picks one set of colored chips that are used to keep track of reputation. These reputation chips are a currency in the game and are used for bidding on and protecting grants. They also serve as a measure of the player's progress toward victory (players start with seven chips and the first player to reach twenty chips is the winner). Five grant opportunities or special events are revealed at the beginning of the game and each player starts with three research cards.

During the course of a round, several grant opportunities are opened for bidding. Reputation chips are used as an abstract measure of a player's academic prowess, career accomplishments, and current availability. To simulate the process of competitive grant proposals, players use their reputation chips to bid on the grant opportunities most appealing to them based on their available resources. Once a grant is won, the reputation chips used to secure the grant are tied to the grant until the grant's requirements have been fulfilled.

Fulfilling a grant involves matching the grant's research requirements by playing research cards of the correct type. Some research cards represent unethical decisions like falsifying data or accepting ghost authorship on a publication. Players may secretly play unethical cards to grants to accelerate their progress, but this also opens them to the risk of being audited for unethical conduct of research by other players. Additionally, players may propose trades of resources with each other, creating collaborative associations. During a trade, players also swap reputation chips thereby associating their reputation with another's decisions and activities. This situation must be approached with caution, especially if the player suspects another researcher of unethical behavior.

When a grant has been fulfilled, it goes into review for one round before being scored and paying reputation chips to the player. This provides the other players an opportunity to audit the grant in review by staking their own reputation chips against those on the grant. Auditing a grant, like any act of whistleblowing, is risky. A player's own reputation suffers if they call into question an entirely ethical research project. If, however, a grant is audited and contains unethical research cards, the grant is removed from review, all unethical cards played on the grant are discarded, and the audited player and any players that have reputation chips associated with that grant lose reputation.

We recruited a total of twenty participants from graduate courses in engineering, computer science, social science, information science, environmental science, and the physical sciences. We conducted two rounds each consisting of two sessions of game play scheduled within one week of each other. This research was approved by our Institutional Review Board (Application No. 13185) on April 23, 2013.

We used the Defining Issues Test (DIT-2) as the instrument for measuring moral judgment (Bebeau & Thoma, 2003). The DIT-2 presents 12 issues after a hypothetical dilemma for a subject to rate and rank in terms of their importance (see Rest et al., 1999). Later in this paper, we will discuss the limitations of and rationale behind the DIT-2 instrument. We used a within subject pre-test/post-test design to determine if each individual's scores for moral judgment were higher after having played the game on two separate occasions. We also developed a survey to measure characteristics of the game including was it fun, challenging, easy to learn, and fair. In addition, the survey included items to explore the strategies employed by the participants including the value and risk associated with collaborating with other players. The survey also sought feedback on the best and worst features of the game and gathered suggestions for improvement.

The DIT-2 data turned up some mixed results, but we did find a significant increase in N2 scores, which suggests that the game may help students overcome some degree of bias in their ethical judgments. The small sample size, however, prohibits us from drawing any strong conclusions until after we have developed our other games and tested all of them with many more students.

4. Challenges of Using Games to Teach Ethics

Our experiences have exposed several challenges involved in ‘gaming’ ethics education. After watching students play “Grants & Researchers,” we think it is possible that games could deliver on at least some of their promised potential to enhance ethics education for STEM students. However, we are struck by the severity of the challenges involved here. Indeed, we believe the three issues outlined in this section pose significant hurdles to the task of ‘gamifying’ ethics education.

4.1 What’s the Right Balance between Learning and Fun?

With any form of ‘edutainment’ a crucial balance between achieving your educational objectives and engaging the students’ interest is necessary. If the balance tips too far one way, the immersive, interactive, and captivating qualities of games are lost; but if it tips too far the other way students are merely playing. Designing a good game – one that is both educational and fun – takes significant investment and skill. The real question is, though, whether it can even be done at all. One could argue that context-sensitive reasoning and careful deliberation are so essential to ethical decision making that there is simply no possible way to cultivate those skills via an enjoyable and practical game, that is, one that could be played in a reasonable amount of time.

One of the aspects of “Grants & Researchers” that we didn’t like was that it was too black and white. The research cards simply said “ethical” or “unethical,” but they didn’t provide any detail about why that was the case. Now, it often made for fun and suspense when someone would play an unethical card and an audit happened. And they were probably learning something about how it feels to be in a situation where you are tempted to cheat in order to get ahead in your career. But the ethical/unethical dualism, we think, is not true to the real-world where decisions are often shrouded in shades of grey. We wanted to build in more discussion among the students about some of the ambiguities in research ethics, but the game mechanics we had chosen worked against us. The discussion would not have been central to driving the game forward, so as the educational value went up, the entertainment value would have gone down.

Perhaps the key is to find ways to make fun and education work together – rather than seeing them as opposite forces in conflict. So, for example, in our second game currently being designed, we are building discussions about ambiguities into the central architecture of the game. That is, students will be rewarded with points when they make persuasive arguments that convince their fellow players to change their minds. In this way, students are motivated to practice their virtues as a natural outflowing of the game mechanics. Nonetheless, we caution that some degree of trade-off between learning and fun may be inevitable, unless a game mechanism is found that can include the rich details necessary for making context-sensitive ethical judgments without diluting the enjoyment of playing a game together with one’s peers.

4.2 Can Cheaters be Winners?

The goal of ethics education is to make STEM students more ethical – to impart a better set of virtues to facilitate more skillful judgments and decisions in their careers. Can that goal be served by having them play an educational game where they can win by behaving unethically? In “Grants & Researchers,” for example, it is possible (though difficult) for a player to win the game by playing ‘unethical’ research cards on their grants.

One could argue that games should be like a morality play and encourage ethical behavior. After all, if cheaters can be winners, then this sends the exact *wrong* message. It essentially trains students to advance their career by becoming more skillful at behaving badly. Perhaps students should win a game only if they made the ethically right decisions.

But this presumes that the “ethically right decisions” are clear. That was the case in “Grants & Researchers” with the simple labels of ‘ethical’ and ‘unethical’ on the research cards. In such a situation, if one could only win by playing the ‘ethical’ cards, then there would be no point in having the ‘unethical’ cards and the game would lose everything that makes it enticing and fun to play. There would be no risk of trying to get ahead by cheating and hoping you don’t get caught and no anguish of trying to figure out whether to audit another player or not. You could design the game in such a way that cheaters are guaranteed to be caught and, thus, not win. But students would quickly figure that out and the game would lose its appeal. It would boil down to compliance ethics, which is one of the simplistic (and dry) features of some other approaches that we are trying to avoid.

In other words, the live option of cheating and winning is important for the entertainment value. But you could also argue that it’s important for the educational value. Consider that in the real world STEM researchers can indeed further their careers by behaving unethically. To create a game where only the good guys win would not be true to real life. It would itself be a kind of lie. It wouldn’t be immersing students in situations that mirror real scenarios (with the same kinds of options, motives, and outcomes).

Another criticism of the morality play approach to ethics games is that it presumes to know what the ethically right decisions are. Yet in real life scenarios, it is often difficult to tell which decision is the best one. So, if we want to make sure only the good guys win, then we would first have to set up a game where the right decisions are clear. Then we would structure the mechanics to steer players down the right path. This too amounts to a kind of lie that does a disservice to the educational potential of games, because choices are often not clear. Games can offer ways to explore the ambiguities of scenarios and try out different actions and arguments without having to worry about real-world consequences.

Finally, the morality play approach may misunderstand how people learn from games. The assumption is that if one cheats in a game, then one is learning to cheat in real-life. But research on video games suggests that behaviors don’t transfer across the “magic circle” between the game world and the real world in such a simple fashion (see Briggle 2012). If they did, then everyone playing violent video games would start murdering people in real life. Cheating in games does not cultivate the habit of cheating in real life, because students are smart enough to understand the difference between games and the real world. But having cheating as a live option in the game does help cultivate a greater awareness of the pressures and temptations that will characterize a STEM researcher’s career. Throwing students into game scenario where cheating is an attractive possibility helps prepare them to grapple with similar situations when they arise in real life.

4.3 How Do We Evaluate Ethics Education?

Assessing the impact of ethics education games is another crucial challenge. Do they lead to better ethical decision-making? This hinges in part on the transferability of learning from virtual to real environments (Cf. Turkel 2009; Peuch 2013). Apart from this general issue, however, we have encountered specific issues when trying to evaluate our ethics education games.

We opted to use the DIT-2 in an effort to measure participants’ pre-to-post game play change in moral development. An obvious issue with the use of the DIT-2 in this context is the apparent mismatch between virtue ethics and the sort of deontological moral theory that underlies the DIT-2. Although we are not entirely comfortable with the DIT-2, we believe that it comes closest of the currently available ethics evaluation tools at measuring the habit we are most obviously targeting for development: the ability to use ethical reflection in decision making.

We are concerned that playing "Grants and Researchers" only two times is not enough to develop the skill of ethical reflection to the point that it becomes an ingrained habit – a character trait – of participants. However, if participants show a significant change in their pre-and-post test scores on the DIT-2, this at least provides *some evidence* that their reflective capacity is increased by playing the game. It should also be noted that infrequent exposure is a problem for almost all approaches to ethics education, especially an approach that just has students click through an online tutorial once. This suggests that one feature of a well-designed game would be that it is easily woven into the full duration of a STEM curriculum. Of course if the game is good, students will *want* to play it again and again.

We still believe that the DIT-2 is the best of the currently available tools for measuring advances in reflection among our study participants. In particular, the DIT-2 is consistent with our approach of teaching ethics as a set of skills rather than a strict method or decision procedure. We are not teaching to the test; so we do not think a test that measures how well students have learned to use a specific decision procedure (such as Mumford's sensemaking approach that teaches – and tests – the ability of students to learn and use specific strategies to enhance ethical decision making) is an appropriate measure for what we are trying to teach (see Kligyte et al. 2008). Further, although earlier research suggested that the DIT and DIT-2 suffered from researcher framing effects that lent the instrument a political bias (see Emler et al. 2007), later studies have vindicated the DIT-2 "as a measure of ethical development, not an expression of political position" (Bailey 2011, p. 314).

However, we believe that better evaluation tools need to be developed. Thus, in the early stages of our second game, we are creating our own evaluation scheme tentatively titled a "mindfulness rubric." We are going to create scenarios with potential responses and use input from a wide range of experienced professionals to rank the responses from best to worst. We can continue to refine the scenarios, responses, and rankings as the game is played over time. Indeed, this could all be made available on an open-source basis. This second game is using digital devices, so the use of our own evaluation instrument will allow us to collect data in real-time as the game is played. We will be able to compare student outcomes in the game (e.g., wins and losses) to their mindfulness scores as well as track scores longitudinally through a single game or even multiple games.

5. Conclusion

Designing a good game for ethics education is challenging. Important questions remain about how to harmonize learning and fun, whether unethical behavior should be allowed as a winning game strategy, how to evaluate the success of games in cultivating ethical skills, and how to integrate games into the STEM curriculum. Nonetheless, we believe these are not insurmountable challenges. Indeed, they are worth the struggle because of the potential pedagogical benefits of games. STEM educators should take games seriously. Their immersive, interactive, and engaging qualities make them a promising way for STEM students to practice the skills they will need to be responsible professionals.

References

Annas, J. (2002). Moral knowledge as practical knowledge. *Social Philosophy and Policy*, *18*(2), 236–56.

Anscombe, G.E.M. (1958). Modern moral philosophy. *Philosophy*, *33*(124), 1–19.

Bailey, Charles. (2011). Does the Defining Issues Test measure ethical judgment ability or political position? *The Journal of Social Psychology*, 151(3), 314-330. Barab, S. A., Scott, B., Siyahhan, S., Goldstone, R., Ingram-Goble, A., Zuiker, S. J., & Warren, S. (2009). Conceptual play as a curricular scaffold: Using videogames to support science education. *Journal of Science Education and Technology, 18*, 305-320. doi: 10.1007/s10956-009-9171-5.

Barrows, H. S. (1986). A taxonomy of problem based learning methods. *Medical Education*, *20*, 481-486.

Bebeau, M. J. and Thoma, S. J. (2003). Guide for DIT-2. Published by the Center for the Study of Ethical Development, St. Paul, MN: University of Minnesota Press, 18-19.

Beecher, H. (1966). Ethics and Clinical Research, *New England Journal of Medicine*, *274*, 1354–60.

Bird, Stephanie J. (1999). Including Ethics in Graduate Education in Scientific Research, In *Perspectives on Scholarly Misconduct in the Sciences*, John M. Braxton, ed. Columbus: Ohio State University Press.

Bird, Stephanie J., and Adam Briggle. 2005. "Research Ethics: Overview," in *Encyclopedia of Science, Technology, and Ethics*, Carl Mitcham, ed. (New York: Macmillan) vol. 3, pp. 1599-1607.

Bransford, John D., A. L. Brown, and R. R. Cocking. (1999). *How People Learn: Brain, Mind, Experience, and School*. Committee on Developments in Science of Learning and Commission on Behavioral and Social Sciences and Education. Washington DC: National Academies Press.

Briggle, A. (2012). The ethics of computer games: A character approach. In J.R. Sageng, T.M. Larsen, & H. Fossheim (Eds.), *The Philosophy of Computer Games* (159-174). London: Springer.

Briggle, Adam and J. Britt Holbrook (2015). "Games," in *Ethics, Science, Technology, and Engineering: A Global Resource*, eds. J. Britt Holbrook (Editor in Chief) and Carl Mitcham (Associate Editor), 4 vols. Farmington Hills, MI: MacMillan Reference USA, 2015, vol. 2, pp. 331-32.

Briggle, A., and Mitcham, C. (2012). *Ethics and science: An introduction*. Cambridge: Cambridge University Press.

Broad, W.J., and Nicholas Wade. (1982). *Betrayers of the Truth: Fraud and Deceit in the Halls of Science*. New York: Simon and Schuster.

Commission on Research Integrity (CORI). (1995). *Integrity and Misconduct in Research.* Washington, DC: U.S. Department of Health and Human Services, Public Health Services.

Deutsche Forschungsgemeinschaft (DFG) Commission on Professional Self Regulation in Science. (1998, revised 2013). "Proposals for Safeguarding Good Scientific Practice," available at: http://www.dfg.de/download/pdf/dfg_im_profil/reden_stellungnahmen/download/empfehlung_wiss_praxis_1310.pdf.

Emler, N., Tarry, H., & St. James, A. (2007). Principled moral reasoning and reputation. *Journal of Research in Personality*, 41, 76–89.
Federation of American Scientists. (2006). *Harnessing the power of video games for learning*. Final Report of the Summit on Educational Games. Retrieved from http://www.fas.org/gamesummit/Resources/Summit%20on%20Educational%20Games.pdf.

Gee, James Paul. 2007. What Video Games Have to Teach Us about Learning and Literacy. Rev ed. New York: Palgrave Macmillan.

Grants and Researchers. (2013). Retrieved from https://www.youtube.com/watch?v=L4Jk84HlLN8&feature=youtu.be.

Holbrook, J. Britt and Adam Briggle (2014). "Knowledge kills action – why principles should play a limited role in policy-making," *Journal of Responsible Innovation* **1** (1): 51-66. DOI: http://dx.doi.org/10.1080/23299460.2014.882554.

Hollander, R. (Ed.). (2009). *Ethics education and scientific and engineering research: What's been learned? What should be done? Summary of a workshop*. Center for Engineering, Ethics, and Society. National Academy of Engineering. Washington, D.C.: The National Academies Press.

Institute of Medicine and National Research Council (2002). *Integrity in Scientific Research: Creating and Environment that Promotes Responsible Conduct*. Washington, DC: National Academies Press.

Jones, G., Warren, S. J., & Lin, L. (2011). Usability and play testing: The oft missed assessment. In L. Annetta & S. Bronack (Eds.), *Serious Educational Assessment* (131-146). London: Sense Publishers.

Kalichman, Michael (2009). "Evidence-Based Research Ethics," *American Journal of Bioethics* 9 (6-7): 85–87. doi: 10.1080/15265160902923457.

Lenhart, A., Arafeh, S., Smith, A., Macgill, A.R. (2008). *Writing, technology, and teens*. Pew Internet & American Life Project. Retrieved from: http://www.pewinternet.org/~/media/Files/reports/2008/PIP_Writing_Report_FINAL3.pdf.pdf.

Kligyte, V, RT Marcy, EP Waples, ST Sevier, ES Godfrey, MD Mumford, and DF Hougen. 2008. "Application of a Sensemaking Approach to Ethics Training in the Physical Sciences and Engineering," *Science and Engineering Ethics*, vol. 14, no. 2 (June) pp. 251-278.

Lenhart, A., Arafeh, S., Smith, A., Macgill, A.R. (2008). *Writing, technology, and teens*. Pew Internet & American Life Project. Retrieved from http://www.pewinternet.org/~/media/Files/reports/2008/PIP_Writing_Report_FINAL3.pdf.pdf.

McDaniel, Rudy, and Stephen M. Fiore. 2010. "Applied Ethics Game Design: Some Practical Guidelines." In Ethics and Game Design: Teaching Values through Play, edited by Karen Schrier and David Gibson, 236–254. Hershey, PA: Information Science Reference, IGI Global.

Mumford, M., Connelly, S., Brown, R.P., Murphy, S.T., Hill, J.H., Antes, A.L., Waples, E.P., Devenport, L.D. (2008). "A Sensemaking Approach to Ethics Training for Scientists: Preliminary Evidence of Training Effectiveness," Ethics & Behavior 18 (4): 315-339.

National Institutes of Health (NIH). 1989. "Requirement for Programs on the Responsible Conduct of Research in National Research Service Award Institutional Training Programs." *NIH Guide for Grants and Contracts*. 18 (45): 1. http://grants.nih.gov/grants/guide/historical/1989_12_22_Vol_18_No_45.pdf.

National Research Council and National Academy of Engineering (NRC). 2014. *Emerging and Readily Available Technologies and National Security A Framework for Addressing Ethical, Legal, and Societal Issues*. Washington, DC: The National Academies Press.

National Science Foundation (NSF). 2009. “Responsible Conduct of Research.” *Federal Register* 74 (160): 42126<en>42128. http://www.gpo.gov/fdsys/pkg/FR-2009-08-20/html/E9-19930.htm.

Puech, Michel. 2013. “The Ethical Experience: Online/Offline.” Presented at the annual meeting of the Society for Social Studies of Science, October 9–11, San Diego, CA. http://www.slideshare.net/mpuech/mp-san-diego-2013-10

Prensky, Marc. 2001. Digital Game-based Learning. New York: McGraw Hill.

Rest, James, Darcia Narvaez, Stephen Thoma, and Muriel Babeau. (1999). DIT2: Devising and testing a revised instrument of moral judgment. *Journal of Educational Psychology*, *91*(4), 644-659. Instructions for ordering DIT-2 can be found at: http://ethicaldevelopment.ua.edu/to-purchase-online-dit1dit2/.

Rhoades, Lawrence, and Andrzej Górski. (2000). “Scientific Misconduct: An International Perspective,” *Science and Engineering Ethics*, vol. 6, pp. 5-10.

Sadowski, Jathan, Seager, T., Selinger, E., Spierre, S., and Whyte, K. (2012). An experiential, gametheoretic pedagogy for sustainability ethics. *Science and Engineering Ethics*, DOI 10.1007/s11948-012- 9385-4.

Schienke, E., Baum, S., Tuana, N., Davis, K. & Keller, K. (2010). Intrinsic ethics regarding integrated assessment models for climate management. *Science and Engineering Ethics*. DOI 10.1007/s11948-010-9209-3.

Schienke, E., Tuana, N., Brown, D., Davis, K., Keller, K., Shortle, J., Stickler, M. & Baum, S. (2009). The role of the NSF broader impacts criterion in enhancing research ethics pedagogy. *Social Epistemology*, *23*, 317–336.

Steneck, Nicholas H. (2004). *Introduction to the Responsible Conduct of Research*. Washington, DC: Government Printing Office.

Steneck, Nicholas, and Ruth Bulger. 2007. “The History, Purpose, and Future of Instruction in the Responsible Conduct of Research.” Academic Medicine 82 (9): 829–834.

Swazey, Judith P. and Bird, Stephanie J. (1997). "Teaching and Learning Research Ethics" In *Research Ethics: A Reader*, Deni Elliott and Judy E. Stern, eds. Dartmouth, NH: University Press of New England.

Toulmin, Stephen. (1982). How medicine saved the life of ethics. *Perspectives in Biology and Medicine*, *25*, 736-750.

Tuana, Nancy. (2010). Leading with ethics, aiming for policy: New opportunities for philosophy of science. *Synthese*, *177*(3), 471-492.

Turkle, Sherry. 2009. *Simulation and Its Discontents*. Cambridge, MA: MIT Press.