gamevironments

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The Ethics of Citizen Science and Knowledge Games. Five Emerging Questions About Games that Support Citizen Science

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Abstract
Citizen science games such as *Foldit* (2008), *EteRNA* (2010), *Eyewire* (2012), and *StallCatchers (*2016) have been increasingly used to produce new knowledge. These games rely on the participation of the public – often *amateurs* or nonscientists – to help solve large-scale problems by contributing and analyzing information through a game. We can call these games *knowledge games*, as they enable researchers and the public to work together to produce new knowledge. However, there has been little attention to the ethical and social implications of knowledge games, possibly because they constitute a small proportion of both games and citizen science activity and because their goals are societally beneficial, e.g., cure cancer, halt Alzheimer's disease. The purpose of this article is to explore and deliberate the ethical complexities of knowledge games. Five key areas of concern emerged from a literature review of related domains: data (How is data collected, managed, analyzed, manipulated, and used?), the game's context (How does using a *game* affect knowledge production?), accessibility (Is the game accessible and equitable in participation?), participation dynamics (How are players valued?), and design (How are ethics embedded in the game's design and what is the impact?). Recommendations and next steps are discussed.

Keywords: Ethics, Citizen Science, Games, gamevironments

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In this article, I investigate an understudied area of gaming: the ethics of designing and using knowledge games. Knowledge games are playful experiences that support citizen science, crowdsourcing, and other participatory activities, such as gathering and processing data, solving problems, and sharing perspectives (Schrier 2016, Brabham 2013). These types of games have been used to align sequences of DNA and rRNA, e.g., *Phylo* (2010) or *Borderlands Science* (2020), classify images (*Eve Online*'s *Project Discovery* (2003), and screen for bladder cancer (e.g., *Reverse the Odds* [2014]) (Kawrykow et al. 2012, Waldispühl et al. 2020, Sullivan et al. 2018, Smittenaar et al. 2018).

Public engagement in science is not a new phenomenon, as amateurs have been contributing to knowledge of our world for hundreds of years (e.g., variable stars, bird watching, and botanical data) (Schrier 2016, Keener 1992, Follett and Strezov, 2015, Dickinson and Bonney 2012, Schrier 2017a). However, the last two decades have seen an increase in the use of citizen science to help solve open questions and to contribute to scientific knowledge (Cavalier, Hoffman and Cooper 2020, Cooper 2016, Lukyanenko et al. 2020). Recently, people have also been invited to contribute data and solve scientific problems through games (Schrier 2016).

The use of citizen science and volunteer participants, such as through sociotechnical platforms like mobile applications, websites, and games, poses a unique challenge to the policies and paradigms around scientific research (Rasmussen and Cooper 2017, Rasmussen and Cooper 2019). Current regulating bodies and guidelines may not fully consider the complexities and practices of citizen science or knowledge games today (Ferretti et al. 2021). For instance, while some citizen science research projects use IRB (Institutional Research Board) and follow federal guidelines, they may not consider how data and labor is used in a *living, breathing* entity such as a game (Franz and

Murphy 2019). Developing relevant ethical, equitable, and humane principles and policies around knowledge games is imperative. As Rasmussen and Cooper (2019, 5) explain, "Because scientists and citizen science practitioners are humans, and because humans err (or worse), we should expect that problems in the field will arise. We should not wait for a problem [...] we should find and prospectively address potential problems."

To do this, we should consider issues such as public engagement in knowledge production; relationships between amateurs and professionals; trust, transparency, and secrecy; biases in design; privacy and fairness; the use of labor; algorithmic design; equity and accessibility; addiction; and the limits of data analysis.

Despite the urgent need to explore these topics, researchers have only started to investigate this area (Deterding et al. 2015, Schrier 2016, Kreitmair and Magnus 2019). This article aims to fill this gap by exploring these issues and identifying open questions and possible solutions.

Citizen Science

Citizen science describes the process of including the public in scientific activities, such as collecting, interpreting, analyzing, assessing, manipulating, categorizing, and/or responding to data, images, and artifacts of some kind, which helps to solve real-world scientific problems (Dickinson and Bonney 2012, Eitzel et al. 2017, Schrier 2017a). Citizen scientists have contributed observations, categorized images, analyzed specimens, and provided interpretations of COVID-19 (Katapally 2020), birds (e.g., Audubon Society/Cornell Lab of Ornithology's *eBird* [2002]), bugs (e.g., SFSU's ZomBee Watch [2012-2021]), eels (e.g., Norrie Point's Hudson River eel project [2009-

2021]), earthquakes (Lee et al. 2020), and even gravesites (e.g., Geological Society of America/EarthTrek's Gravestone Project [2011]). Other examples of citizen science include Zooniverse's *Galaxy Zoo* (2017) (and its spinoffs), in which participants help to classify real images of galaxies photographed by the Hubble telescope (Zooniverse n.d.). In Zooniverse's Manatee Chat, people can identify, classify or categorize manatee vocalizations (Zooniverse n.d.).

Citizen science-type activities do not have to be only focused on *scientific* problems; they can also focus on social, civic, and humanistic problems (Pettibone et al. 2017). People have transcribed historical documents related to a 1959 research trip to the Caribbean for the Smithsonian Institute (Smithsonian n.d.). The CommunityCare platform crowdsources mental health needs, while LiquidFeedback from Germany and DemocracyOS from Argentina crowdsource civic and policy-making needs (Suran et al. 2020, Ronzhyn et al. 2020, Spitz et al. 2018).

Citizen science is effective in part because it enables researchers to distribute the many observational or interpretive tasks to many people (Wiggins and Crowston 2012, Schrier 2016, Schrier 2017a). So, instead of having one person or one lab do all of the data collection or manipulation, researchers can invite a larger number of people to observe nests, listen to manatees, or transcribe historical documents, which helps scientists better build knowledge and collectively answer real-world questions (Schrier 2016, Dickinson and Bonney 2012, Eitzel et al. 2017).

Games and Citizen Science

Games and playful environments are being used to motivate and engage participants in citizen science activities (Ponti et al. 2018, Kreitmair and Magnus 2019, Ponti et al.

2015, Keyles 2021, Greenhill et al. 2016, Schrier 2016). These games have been called citizen science games (Ponti et al. 2018), as well as knowledge games (Schrier 2016), human computation games (von Ahn 2005), or games with a purpose (GWAP) (Law and von Ahn 2011), with no clear consensus on the name (Schrier 2017b). The terms used are not neutral – language matters and it has ethical implications we should further critically evaluate (Schrier 2017b, Guerrini et al. 2019, Eitzel et al. 2017, Cooper, Hawn and Larson 2021). However, for the purposes of brevity, we call these types of games *knowledge games*, as they seek participation from human game players to solve real-world problems, address complex ideas, and produce new knowledge (Schrier 2016). These games could be digital, or they could be analog.

A classic example of a knowledge game, *Foldit* (2008), was made by University of Washington researchers, enables players to solve protein folding puzzles together (Cooper 2014). Game players have helped researchers predict real protein structures, such as ones related to HIV (Cooper et al. 2010, Khatib et al. 2011, Khatib et al. 2019). This game helps solve complex problems, in part, because it partners human beings with computers: computers have fast processing abilities, while human beings can intuitively manipulate protein structures. *Foldit*, thus, optimizes the abilities and skills of both humans and computers such that, working together, they are able to accomplish more than each could separately (von Ahn 2005).

The themes of efficiency, effectiveness, and speed also appear in many other knowledge games. *EteRNA* (2010) crowdsources designs for new RNA molecules, which players create to fight against specific diseases, such as Tuberculosis and COVID-19 (Perkel 2018, *EteRNA* 2020, Schrier 2021). Likewise, in the game *Mozak* (2015), players trace neurons; in *Eyewire* (2012), participants map neurons in the brain; and in *Play to Cure: Genes in Space* (2014), players analyze breast cancer data.

Players of EyesonAlz’s *StallCatchers* (2016) game were able to analyze Alzheimer’s data in one month, in what would have taken a year for their lab to analyze. Likewise, in *Sea Hero Quest* (2016), players contribute to research related to dementia. According to their website, playing the game for two minutes contributes the same amount of research as scientists working for five hours. Since it has been played for over 111 total years by game players, the scientists have already collected 167 centuries worth of dementia-related research (*Sea Hero Quest* 2016).

ScienceAtHome has different games for different scientific problems, such as *Quantum Moves* (2012), which helps to build a quantum computer (Lieberoth et al. 2014); *Turbulence* (2017), which helps understand open questions in classical physics, and the *Network game* (n.d.), which helps solve computation-related problems. Their series of games, *Skill Lab: Science Detective* (2018), helps to understand how people make decisions and solve problems, so computers and human beings can work together more efficiently (ScienceatHome n.d.).

Citizen science-type tasks also appear inside of commercially-popular virtual and game worlds. In *Eve Online*'s *Project Discovery*, game players analyze real human cells. Completing these tasks then gives these *Eve Online* players points and rewards, which help them to play the *Eve Online* game and level up their game character (Sullivan et al. 2018). Games based on the knowledge game, *Phylo*, are also being played in *Borderlands 3* (2019), with players averaging 10,000 to 15,000 hours of work each day on problems related to aligning genomic sequences (Waldispühl et al. 2020, Kawrykow et al. 2012, Muoio 2020).

Knowledge games are also being used to solve social, humanistic, and cultural issues, such as bullying, e.g., *SchoolLife* (2013) or peace in the Sudan, e.g. *The Sudan Game*

(Landwehr et al. 2013, Schrier 2016). Games are being used to better understand civic needs and human behavior (Spitz et al. 2018, Vicens et al. 2018, Schrier 2021, Heiss and Matthes 2017). Knowledge games have been particularly effective in solving so-called *wicked* problems that require different types of perspectives and expertise, such as ones related to health, environmental issues, or social scientific needs (Introne et al. 2013, English et al. 2018, Bietz et al. 2019, Lee et al. 2020, Spitz et al. 2018). Although knowledge games make up a small proportion of games being created and of citizen science projects (see figure 1), they are increasing in use, have an impact on knowledge production, and bring up important ethical implications.

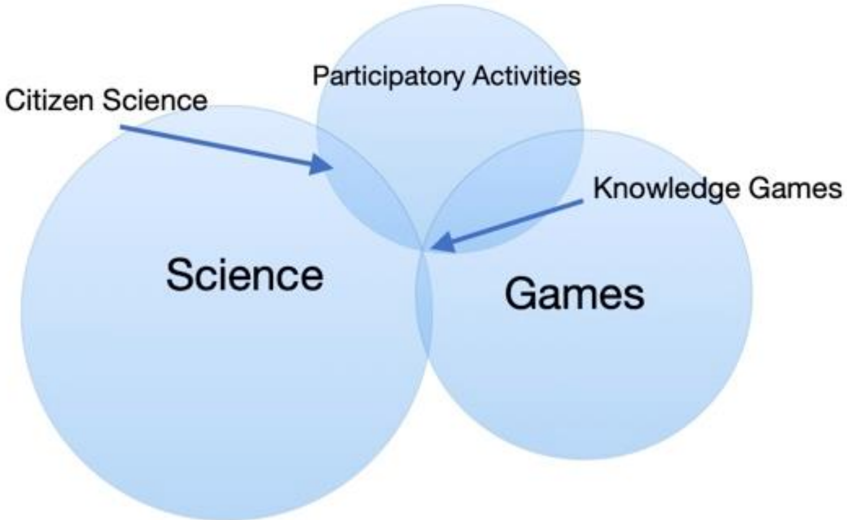

Figure 1. Games are a small proportion of citizen science, and citizen science is a small portion of crowdsourcing-related projects and the field of science as a whole.

Methodology

As we continue designing, making, and using knowledge-producing public-participating games, we need to consider their ethics. By ethics, I mean, the cognitive, social, and reflective processes related to applying moral principles to scenarios, decisions, and choices (Schrier 2021, Schrier 2015, Wines 2008), or questions of right or wrong in human behavior and actions (Meng, Othman, D'Silva and Omar 2014). While ethics and morals often get used interchangeably, morals often refers to "universal truths, or public rules or principles" (Tierney 1994, ix), or the code of conduct that affects how people make decisions or act (Wines 2008). There are many ways to define whether a choice, activity, attitude, or behavior is ethical, such as using utilitarian, hedonism, deontological, or Kantian ethics approaches (Shafer-Landau 2010), and there may be different moral orientations or approaches used to decide is something is ethical (Levitt and Aligo 2013); such as a justice-oriented approach to ethics (maintaining equality and fairness, cf. Botes 2000, Glover 2001) or a care-oriented approach (maintaining relationships and other's needs, cf. Botes 2000, Gilligan 1987, Noddings 2003). Moreover, the ethics, norms, and moral understandings of an individual or community may rapidly evolve over time or even between contexts or types of practices (Levitt and Aligo 2013, Schrier 2014, Schrier 2015). The ethics of playing a knowledge game in an online gaming community like *Borderlands Science* may be different than in a classroom with elementary kids.

As a first step, we need to identify open questions around knowledge games. To begin, I pose five themes to consider further, inspired by boyd and Crawford's article, "6 Provocations for Big Data" (boyd and Crawford 2011). To identify these themes, I conducted a systematic literature review in which I searched databases using pre-established search terms (Adroher et al. 2018, Fink 2019, Okoli 2015). As there is limited research literature specifically on the intersection of ethics, citizen science, and games, to generate these possible ethical ramifications, I conducted a search of relevant literature using the following combinations of terms: (1) ethics and citizen science and (2) ethics and citizen science and games. During early October 2021, I searched a sample of databases for peer-reviewed journal articles from 2010 to current: ACM Digital Library, ProQuest, Academic Search Elite (EBSCO), and Google

Scholar (Okoli 2015, Xiao and Watson 2019). I chose these four databases as they are available through my library, and have been used to conduct other literature reviews related to gaming (Schrier 2015, Schrier and Farber 2021).

To generate the body of literature, I looked at the top 50 most relevant articles for each search, and then reviewed them for relevance to the topic (being *ethically-related*). I define issues as being *ethically-related* if they concern personal, interpersonal, cultural, or societal norms, justice, values, morals, or other ways in which we need to act, behave, decide. For instance, an article, "Hunter estimates of game density as a simple and efficient source of information for population monitoring: A comparison to targeted survey methods" (Hušek, Boudreau and Panek 2021), was deemed irrelevant as it referred to wildlife game rather than games we play. Other articles like "How Much Do We Know About Contributors to Volunteered Geographic Information and Citizen Science Projects" (Mooney and Morgan 2015) may be relevant to citizen science, but this one only referred to ethics in the works cited. In addition, I supplemented my systematic search with other relevant literature that I found cited in the ethically-related articles, as well as in related domains like critical technology studies, data studies, and game studies.

Five Ethics Themes

In this section, I describe the five ethics-related themes that emerged in the literature.

Data. How is Data Collected, Managed, Analyzed, Manipulated, and Used?

Just as with any research study, we need to consider how data is collected, mined, analyzed, managed, and shared in a game, and beyond a game. Additionally, we need to apply these questions to how we collect and use data in a game environment, and consider how this may differ from that of other research and citizen science contexts. How might data be read differently through a game, and how might it be altered when we use it to play with, interact with and/or simulate systems?

Accuracy, Quality, and Trust

In the literature review, many ethics-related questions centered on the accuracy and quality of contributions made by the public, and whether the results of these projects can be trusted (e.g., Guerrini et al. 2018). Liu et al. (2020) found differences in how citizen players and expert scientists approached drug design and engaged with the interface of *Foldit*. Foody et al. (2013) investigated the accuracy and quality of crowdsourced data from a Geo-Wiki tool for land cover validation, and found differences in how experts versus non-experts identified land cover type. Researchers have cited anonymity, lack of training for participants, and the ease of making errors as reasons to distrust public contributions (Ceccaroni et al. 2019). Intentional mistakes and even purposeful disinformation may be shared through a game (Schrier 2021).

On the other hand, many researchers have found public participation in knowledge production to be effective. Lintott et al. (2008) compared the data categorizations made by the general public to those made by professional astronomers, and found no significant differences. A study by Ivanjko (2019) suggested that the annotations applied to cultural heritage-related images by game players were suitable. Strobl et al. (2019) used a game where players verify water data collected by the public through a mobile application (app), and found that the players helped to identify errors made through the app. Moreover, Lukyanenko et al. (2020) describe a number of discoveries that were made by citizen scientists, including a new type of aurora, a lost satellite, and a rare ladybug.

Regardless of whether accuracy is maintained, there also remains a general lack of trust about the reliability of scientific data collected through citizen science (Catlin-Groves 2012, Weber et al. 2019), as well as a lack of trust in scientists themselves (Roy and Edwards 2019). Scientists may even be undermined by the public, leading to potentially devastating and dire real-world consequences (Roy and Edwards 2019). Trust needs to be carefully earned and respected when, for instance, scientists collect data from indigenous communities or when they invite patient health data (Milek 2018, Majumder and Maguire 2020, Borda et al. 2019, Bietz et al. 2019, Wiggins and Wilbanks 2019).

A number of researchers posit strategies for mitigating errors (Budde et al. 2017). Researchers cite ways to support data quality, such as having multiple people validate others' data or interpretations, offering training, asking additional questions around contributions that may be inconsistent, or using volunteers who are designated to review contributed work (Preece 2016, Sheppard and Terveen 2011, Wiggins and He 2016). Strategies may also include checks for spam and malicious submissions, tampering with or falsifying data, cheating or breaking rules, and intentional mischief, all of which could also happen within games (Preece 2016, Roy and Edwards 2019, Consalvo 2007, Hunter 2021). Rasmussen (2019) explores what we might do, ethically, when misconduct does happen. A competing tension to this is the need for game players to be able to *fail* or make mistakes, as failing and iterating also help lead to learning, experimenting, and solving problems (Lukyanenko et al. 2020, Schrier 2021). How can knowledge games balance these differing needs?

Privacy and Transparency

Ethical issues around privacy and transparency have also emerged from the literature (Bowser et al. 2017, Cooper et al. 2021, Guerrini et al. 2018). People may have an incorrect conception that playing with data, even anonymized data, is risk-free, but it still has privacy concerns (boyd and Crawford 2012). Initially, when citizen scientists were identifying bugs or folding proteins, privacy concerns may not have seemed as salient. But now, as more projects have included personal and human data – like biomedical and community projects – privacy concerns have moved to the foreground. Borda et al. (2019, 8) write that, "the more closely-associated a project is with the participant (e.g. in the home or the individual person), the greater the potential for legal, ethical, privacy, biosafety and data management and ownership complications to be raised.... It is, therefore, necessary to consider what shared standards, methodologies and practices might be applicable."

Researchers note that those developing citizen science projects and games need to address privacy and transparency concerns, such as handling personally-identifiable data and location-based data, or how to handle permissions when given access to someone's social media (Eleta et al. 2019, Preece 2016, Bowser et al. 2014, de Vries et al. 2019, Cooper et al. 2019). Researchers have also noted that emerging technologies such as the use of Internet of Things (IoT) devices or artificial intelligence in collecting and interpreting information bring up further privacy concerns (Scheibner et al. 2020, Ceccaroni et al. 2019).

While websites and games are required to post privacy notices and gain consent to their agreements, many people skip reading these very complex documents, even if they really do want to know how their data is being used (Andrejevic 2014). Players may feel that they must share this data to participate in a game. Eleta et al. point out that informed consent may work differently in different contexts, so designers need to shape this accordingly (2019). An IRB (institutional research board) typically reviews consent procedures and verifies that the use of data is not harmful to participants, but it is less clear if the IRB process or Belmont study principles are always applied to knowledge games. Moreover, Cooper et al. (2019) and Oberle et al. (2019) describe how institutional oversight as it is currently structured may not be adapted to citizen science activities, including ones that use gaming. They found that some of the citizen science projects currently do not include informed consent procedures even though they collect personally identifiable information, nor do they explain how they will handle this data (Cooper et al. 2019). Since motivational messaging (and perhaps a motivational game or game livestreamer) may encourage players or observers of a game to share more data than they want to consent to, we need to take additional privacy precautions and ensure that we do not encourage disclosure unethically (Rudnicka et al. 2019, Deterding et al. 2015, Reiheld and Gay 2019, Martelaro et al. 2021).

Furthermore, the literature described issues around transparency. Transparency is defined as the act of looking at the values and decisions that govern how a project, research process, or game is designed (Cooper et al. 2021, Elliott 2017). For instance, data may be used in one way, and then sold or reused for a totally different purpose. The participant may not be aware of all the future ways their data may be used – ways that they would not have consented to (Kosciejew 2013). A study found that most participants do not want their citizen science data shared with or sold to a company (Ferster et al. 2013, de Vries et al. 2019). Thus, people may feel disempowered and perhaps even oppressed when it comes to sharing data – they lack understanding in how their data will be used, but they also lack control over what will happen to it (Andrejevic 2014). In fact, Bowser, et al. (2020) found that a number of projects are lacking in open access to data and making transparent the pros and cons of their data infrastructure.

Bowser et al. (2014) recommend ensuring different privacy options for personal data and giving participants control over these options; allowing volunteers to hide, delete and modify their data; and requiring only the minimum data that is necessary to be shared in a study. Preece (2016) suggests that players' privacy be protected from others harming them based on the data they share through a game – especially if players share location-based data. Oberle et al. (2019) recommend a new approach to ethically reviewing these projects that takes into account the extent to which participants are co-producers of the research, and I would add, how the technology might challenge these relationships. Likewise, Bowser et al. (2020) also suggest researchers and participants work together to develop standardized and ethical privacy and data governance policies and terms of use.

There are a number of frameworks that might be useful. Cooper et al. 2021 cites a framework on privacy by Nissenbaum (2004) called Privacy 3.0, which puts at the forefront the participants' needs and control of their own data. Preece (2016) recommends work by Cavoukian (2011) on principles for designing for privacy.

To add to the complexity of these issues, there are tensions between privacy restrictions and the ability to rapidly innovate. Evans (2020) points out that maintaining privacy parity with other types of research protocols (including lengthy FDA approvals or other types of compliance like HIPAA) may hinder the ability of many participatory science programs from moving forward and making real-world change. Evans suggests alternatives to privacy protections such as ensuring no sharing of data without permission, or only including participants who do not value privacy (2020). Cooper et al. (2019) recommend that all stakeholders (including game designers and players) determine the best ways to mitigate risks while allowing for innovation and growth.

In terms of transparency, Eleta et al. (2019) call for accountability and greater transparency in these projects, such as an understanding of any conflicts of interest, uses of data, timeline of project, or steps in the process. On the other hand, Quinn (2021) looks at a case study of herpers (people who look for reptiles or amphibians) and their communally created system of both sharing and protecting knowledge. Quinn argues that there is a value to secrecy of information and methodologies for some knowledge-producing communities (2021). Bowser et al. (2017) advocate for considering the context of the project alongside the participants' level of openness with the sharing of data. As we develop knowledge games, we need to be mindful of the context and community and how data should be shared, used, and interpreted. Likewise, Cooper et al. (2021) recommend the use of ethical principles around data access, management, and stewardship (for instance, taking into consideration the need to keep personal data private as well as the need for sovereignty over one's contributions).

Analysis of Data

The literature review also identified ethical questions around how data is analyzed, particularly as projects begin to apply artificial intelligence (AI) and machine learning techniques (Ceccaroni et al. 2019, Zidaru et al. 2021). The ability to collect and interpret lots of data by a variety of game players furthers larger questions about data sets and how those are analyzed, used, and acted upon. Consider how much data is being collected through games like *Eve Online* or *Borderlands 3*.

> "How the data get shaped, cleaned, and filtered also affect how the data are interpreted and used. Data analysis is always limited and biased, soft and pliable." (Schrier 2016, 170, citing boyd and Crawford 2012)

Big data analysis techniques may, for example, call attention to patterns in behaviors that have not been able to be seen before (Andrejevic 2014, Schrier 2016). For instance, though we typical create hypotheses prior to the analysis, with big data, researchers may rely less on hypothesis testing, and instead look for strong correlations within a large data set (Cukier and Mayer-Schönberger 2013). However, this means that the mistake of *correlation is not causation* (Cukier and Mayer-Schönberger 2013) still exists, but on a greater scale. Bigger data sets do not mean they are more accurate or high quality, it could mean there is more data that is erroneous, unrepresentative, or inaccurate (Schrier 2016). Even if the data is accurate and ethically collected, we still need purveyors, interpreters, and communicators. People need to "reshape data into actionable and meaningful knowledge and reflect on its implications and consequences" (Schrier 2016, 178), as data is not knowledge.

Moreover, knowledge game designers may use approaches like natural language processing, machine learning and AI, coupled with public participation, to analyze large data sets, generate large data sets, or to *teach* and *train* these systems (Sabou et al. 2012, Martelaro et al. 2021, Lotfian 2021). Lotfian (2021) discusses the use of citizen science to train machine learning algorithms to better identify species. Ceccaroni et al. (2019) discuss challenges in labeling data sets to properly train AI and develop models. Martelaro et al. (2021) describes the *Polyphonic project* (n.d), which uses Twitch (a live-streaming platform) to capture audio in the home. How might biases be inscribed in these methods?

Increasingly, the methodologies and types of data that get more easily accepted as *truth* or *fact* are quantitative in nature (boyd and Crawford 2012), suggesting that the questions that get asked, the variables that are considered, and the meaning-making that happens emphasize more quantitative approaches. This limits the use of other methodologies and perspectives, and also limits what we can learn. There are ethical implications in privileging one type of methodology over another, as they can each only reveal a narrow perspective on the world. Most of the articles in this literature search came from the science and health fields. We need more perspectives from the humanities and the arts (e.g., English, STS [Science and Technology Studies], philosophy, political science, design studies, game studies) which also consider the ways data through knowledge games may be analyzed, manipulated, designed, and interpreted (e.g., Milburn and Wills 2021, Franz and Murphy 2019, Preece 2016, Lukyanenko 2020).

Game Context. How do Games as *Games* Affect the Ethics of Knowledge Production?

In this section, I consider public perceptions of games and tensions among work and fun, winning and accuracy, and between scientists and players. How might the public respond to any data or findings, or value it differently because it came from a game?

Games as Fun and Work

Games are typically framed as being *leisure* or even *frivolous* pursuits, though they may have social and educational impact (Schrier 2016, Schrier 2021). Public discourse around games often centers on *moral panics* (being erroneously blamed for causing societal decay like addiction or violence) rather than their possible benefits (Markey and Ferguson 2017). This may affect how games are then accepted and trusted as productive experiences. In fact, the public may see knowledge production and gaming as oppositional, rather than as activities that are complementary (Ponti et al. 2015, Ponti et al. 2018).

Playing knowledge games also complicates the boundary between *fun games* and *serious work* (Schrier 2016). On the one hand, players are playing a game, and on the other hand, they are contributing real work and supporting research. How players and scientists navigate these tensions is only beginning to be analyzed. For instance, one study suggests that a *fun* label may affect how people perform on a task in a game (Higgins 2012). Ponti et al. (2018) found that players of *Foldit* and *Galaxy Zoo* respond differently to the tension between fun and work, and may as a result, value different types of game mechanics.

Likewise, Ponti et al. (2018) uncovered other types of tensions that arise between games and research – such as between doing well in a game and being accurate, as well as the tensions between researchers and players. Each online game and community may have different values and norms that are negotiated by the players, and these may change over time (Ponti et al. 2018, Schrier 2021). Furthermore, the acceptance of a project as being labeled *a game*, and of a particular game being appropriate for scientific knowledge production may differ across communities (Ponti et al. 2018). We need to continue to evaluate how players navigate these tensions, and how this affects knowledge creation.

Even if game players are doing serious work in a knowledge game, games themselves may be viewed as less serious. How do public perceptions of games affect how the knowledge from these games gets made, interpreted, perceived, accepted, and applied? Are games, because they are seen as fun, also able to subvert the act of knowledge-making and give us insight into the artifice of authority? Are they able to push boundaries and liberate us because they are a little foolish (Schrier 2021, Bogost 2013)? Could these games help to challenge bias and critically assess power relationships (Mueller et al. 2012)? Or, are knowledge games another way that work is capitalizing on our leisure time? I will discuss this further in a later section.

Even if games are *work*, the framing of games as less serious, and the designing of games for *fun*, may have ethical implications for knowledge production. For instance, if we take a data set related to a serious issue, like AIDS or cancer, and incorporate it into a fun game where we play with this data, is this appropriate, humanistic, or ethical? Bafeta et al. (2020, 3) identify the need to apply ethical and humanistic principles such as "respect for persons, justice and beneficence (doing what is right), and respect for law and public interest." What if we design a game that invites data from marginalized populations or investigates Indigenous lands (Pejovic and Skarlatidou 2019, Chesser et al. 2019)? Does the *fun* perception reshape a games' seriousness and its ethics? We can look at Cancer UK's mobile game, *Play to Cure: Genes in Space*. In this game, designers took real breast cancer data, and transformed it into Element Alpha, a fuel needed to fly through space. Where the player travels to get this fuel in the game shows the researchers the location of any data anomalies. All of Cancer UK's breast cancer data was analyzed within just a few months, but it converted personal health data (breast cancer data) into something *fun* like space travel (Schrier 2016). Does this game obscure the provenance of the data? Does this game balance respect for persons (care of private health data) with respect for public interest (mitigating breast cancer)? In later sections, I discuss the concept of alienation, or a separation of a person from their expected goal. In the case of *Play to Cure*, there may be an alienation of the cancer patient from what their data will be used for, and alienation of the player from the original source of data. What are the ethical ramifications of this type of distortion of content, context, and goal?

Accessibility and Equity. Is the Game Accessible and Equitable in Its Recruitment and Impact?

In this section, I review ethical issues related to recruiting a representative sample, as well as ensuring equitable and inclusive access to the research. How do we ensure that game players are accurately representative and recruitment is equitable and ethical?

Equitable Recruitment and Participation

Just like with any research study, designers of knowledge games need to ensure they have an accurate sample of target populations. Other sociotechnical platforms, including crowdsourcing and citizen science projects, do not spur equitable participation. Dawson (2018) and Cooper, Hawn and Lawson (2021) found that most participants are white, educated, and from middle to upper classes. Even among participants, engagement is uneven. In one study, Stewart, Lubensky and Huerta (2010, 30) found that participation in online communities is imbalanced and follows the 90-9-1 rule, such that "(a) 90% of users are 'lurkers' (i.e., they read or observe but don't contribute), (b) 9% of users contribute from time to time, but other priorities dominate their time, (c) 1% of users participate very often and account for most contributions."

Currently, only a small portion of people contribute to citizen science projects or to knowledge games – e.g., around 10% of Americans (Pew Research 2020). Even platforms with heavy contributions, such as *Instagram*, *TikTok*, *Twitter*, or *Facebook*, skew toward specific demographics and are not accessible to all different populations. Making decisions like having a primary language (such as English), deciding to use an Internet-based platform or mobile device, or using a digital game will limit who is able to participate. For example, only those with an iPhone or iPad can play *Reverse the Odds*, and only those with Internet access and a computer or mobile device can play most knowledge games (Smittenaar et al. 2018). Although the choice to use a game has ethical implications for who gets to play, contribute, and produce knowledge, using games may also help to reach previously untapped audiences (Newman et al. 2012, Bowser et al. 2013).

Chesser et al. (2019) and Pandya (2012) identified a number of barriers to participation in citizen science, including lack of time, lack of access to natural settings, unfamiliarity with the scientific process, and family responsibilities. "Knowledge production is always embedded in specific social, political and institutional contexts" (Fiske et al. 2019, 618). With a game, however, there are additional considerations related to equity and accessibility. Researchers have cited how game players may face exclusion, bullying, hate and harassment in games, including sexist, ableist, antisemitic, islamophobic, and racist acts and representations (ADL 2020, Gray 2012, Chess 2017, Chess 2020, Kafai et al. 2016, Keum and Hearns 2021). Whether a person will play a knowledge game is affected by their desire to spend their time playing a game, their prior experiences with games, and their self-efficacy around feeling *good enough* to play a game and participate in research (Portnoy and Schrier 2019). Beyond having the right equipment and time to offer, technical literacies, inclusive practices, and perceptions matter (Preece 2016). Knowledge-producing projects should invite more participation from marginalized populations, and people who are outside of the traditional networks (Chesser et al. 2019, Fiske et al. 2019). While we might initially cite the clear need for data from diverse populations, what is also integral is having diverse perspectives, expertise, and experiences designing these projects, and ensuring all different voices are contributing to solving the problems in our world (Chesser et al. 2019, Rowbotham et al. 2019, Schrier 2021, Preece 2016, Qaurooni et al. 2016). Everyone should be able to produce new knowledge.

To put it even more strongly, Lowry and Stepenuck (2021) argue that it is not just useful to be inclusive and less biased – it is essential. They explain, "Without addressing the issues of inclusion, bias, exploitation, and practicability, citizen science may, in fact, die, losing its place in the scientific continuum" (Lowry and Stepenuck 2021, 4195). As Vayena and Tasioulas (2015) argue, we all have a human right to participate in science (and more broadly, all knowledge creation).

Knowledge games should aim to be inclusive and equitable, first and foremost. A knowledge game needs to be designed with consideration to the needs and motivations of marginalized communities, and different abilities and disabilities (Ponti et al. 2018, Anderson and Schrier 2021, Preece 2016). For instance, Preece (2016) discusses a project where people who have sight impairments contribute by listening to bird sounds (Posont 2012). Howlett et al. (2021) discuss a project including people with intellectual disability in citizen science. Pandya (2012) describes a project with the White Earth Nation in Mahnomen, Minnesota that stems from the community's needs and includes tribal leadership in all areas of the project's design.

Fiske et al. (2019) propose an integral list of questions for project designers to ask themselves – such as those related to barriers, distribution of benefits, the development of trust, and their recognition of inequalities. They provide recommendations such as designing with marginalized populations, addressing historical marginalization, reimbursing participants, more accountability and transparency in terms of who benefits from the project, and avoiding tokenistic inclusion.

Pandya (2012) describes a framework for inclusion, which involves aligning with community priorities, continuous engagement with communities, incorporating participants as equal partners with the scientists, and sharing knowledge in appropriate venues, languages, and formats.

Data Divides

As described in the previous section, the literature has revealed a number of equity issues and divides, where some people are able to access and engage with projects, and others are not (Wiggins and Wilbanks 2019, Chesser et al. 2019). This leads to the exclusion of essential contributors to knowledge.

There is another type of divide – a data divide – between those who get access to data and those who do not (Andrejevic 2014), and those who have access to algorithms that guide data use, and those who do not (Allan and Redden 2017). Companies like Google, Facebook and Zynga can use people's personal data for their own corporate benefit, while participants cannot access that data, make decisions about the data, or use it to address the problems they want to solve. Moreover, even if the public had access to the data, they may not know what to do with it or how to make meaning from it (Manovich 2011). The *data-haves* may have the data, but also the literacy and analytical skills to be able to use the data, the storage facilities and computational capabilities and tools to interpret the data, and the reputation and social capital needed to communicate the data's meaning with authority (boyd and Crawford 2012, Andrejevic 2014).

Chesser et al. (2019) recommend a few strategies for bridging this divide. We should find ways to include marginalized populations, not only in data collection, but in activities that directly contribute to interpretation, decision-making, and knowledge creation (Chesser et al. 2019). Next, they recommend adapting project so more people can participate, such as by adapting it into different languages or visual formats, changing the training to meet the needs of the population, or learning more about a particular group's needs to change the way data is collected or interpreted (Chesser et al. 2019, Stevens et al. 2014). Third, they recommend sensitively ensuring that projects consider the backgrounds and traditions of their participants, and are designed *with* the participants, rather than being hoisted upon them (Chesser et al. 2019). Physical, mental and emotional, and cultural safety should also be maintained by project designers. This is particularly important given the lack of ability to supervise a crowdsourced, distributed project (Chesser et al. 2019). Finally, Chesser et al. (2019) recommend that the project be mutually and equitably beneficial for both the research designers and the participants.

However, there is another ethical concern to consider. Increasing participation from everyone may also, simultaneously, increase control over them. Andrejevic argues that organizations and institutions may use their power over data as an instrument of control, and/or to reinforce power structures and social differences (2014). Gandy argues that there is *social sorting* done not only by people's interests or demographics, but also based on what we predict someone will do, which is a type of surveillance or control (Andrejevic 2014, Gandy 1993). Benjamin (2019) argues that all sociotechnical platforms (including games) are designed to recreate the carceral state, and to control and surveil, in particular, *othered* bodies. Marginalized peoples, such as Black, Brown, and Indigenous people, may be more vulnerable when sharing data, and when participating in knowledge games. We need to consider how greater access to participation might endanger certain populations more than others. How do we maintain equity and safety for all?

Power and Participation: How is Power Negotiated and How are Players Valued?

Articles explored in this systematic literature review grapple with questions of power and the nature of the participation itself. Participants (*the public*) are co-creating knowledge with scientists and researchers – or are they? This section explores these dynamics further.

Games and Labor

While games are often labeled as *leisure activities*, researchers like Bogost (2015) and Postigo (2014) argue that games have always been a type of *work*: they are challenging, tedious, and even boring at times. Game playing is labor (or *playbour*) (Kücklich 2005, Banks and Humphreys 2008, Postigo 2009, 2014). Solving problems in *Skill Lab: Science Detective*, contributing RNA designs on *EteRNA*, and folding proteins in *Foldit*, could be considered a type of unpaid, outsourced labor. Although the public provides this gaming labor for free, and may even get benefits from it such as science skills, collegiality, and a sense of belonging, should it be compensated?

We can look at other types of contributory activities, such as making YouTube videos, sending TikToks, or writing blogs as a type of *labor* that conflates the boundary between producer and consumer. Games have encouraged player labor in the creative process of designing the game, such as through modding, or modifying of a game (e.g., Valve's Hammer level editor), through the building of in-game virtual assets or entire games, e.g., *Minecraft* (2009) or *Roblox* (2006), and/or through the creation (and sometimes even selling) of assets through a game, e.g., *Team Fortress 2* (2007). Games may even rely on this labor, such as *Spore* (2008), which enabled the design of millions of monster assets by outsourcing the labor of creation to the players (McElroy 2008). Most of these activities are uncompensated and access to them may even require payment from the player.

How should we treat the labor conducted in knowledge games? Resnik et al. (2015) explain that the interactions among participants and designers need to be mutually beneficial; this could mean sharing authorship, providing ownership of intellectual property, paying money, providing education or giving other benefits. Some researchers recommend paying contributors, and at the very least, citing their work and providing credit (Guerrini and Contreras 2020, Resnik et al. 2015). D'eon et al. (2019) ran a study on Amazon's Mechanical Turk platform and found that more fair payments can lead to an increase in work effort. Adler et al. (2020) argue that it is more equitable to compensate participants, as it will encourage contributions from marginalized groups; however, some projects can only move forward by relying on unpaid work. Work by Cooper et al. (2021, 3) suggests that the traditional model of authorship credit may not fit citizen science activities, and they recommend "the data stewardship practice of licensing a dataset to foster intentional deliberation and decisions related to attribution." We need to think about how to encourage and reward the participation from game players in ethical ways.

Coercion and Exploitation

Through knowledge games, the public is supporting researchers by participating in the data collection, interpretation, and/or even the marketing and communication of the study, which is a form of co-creation (Banks and Potts 2010, Fuchs 2014, Suran et al. 2020, Fuchs 2010). But often game players are not the decision makers or policy makers, and do not have the same level of power as the project leaders (Cooper et al.

2021, Guerrini et al. 2021) Even the label of *amateurs* demarcates the public as being separate from, and not fully equal to the scientists leading these studies (Allan and Redden 2017).

Resnik (2019) and Smith et al. (2019) look at the issues that arise when contributors to research are neither human subjects nor just collaborators, but a combination of the two roles. How do we value the contributors of the game players as both partners and people who are being studied themselves? Are the game players *tokenized* or are they fully empowered and involved (Smith et al. 2019)?

When is cocreation, and this labor, exploitative? Andrejevic argues that exploitation occurs when our activities (such as contributing data or interpretations) are no longer recognizable and meet needs and goals that we do not have; in other words, we are *alienated* from it (Andrejevic et al. 2014, citing Holmstrom 1997). Likewise, Terranova explains that voluntary labor becomes problematic when it is unclear who or what benefits from the labor; and when players become alienated from their purpose in playing the game (Terranova 2000, Campbell 2014). Framing games as *fun* or *leisure* may even reaffirm this type of alienation, because they help to pervade our leisure time without our realization. People may not understand that they are being exploiting, as the exploitation is couched as *fun* (Schrier, 2016, citing Fuchs 2008 and Fuchs 2010).

Even if a particular citizen science activity or knowledge game does not feel exploitative, these projects may foster unequal power relationships that lead to future exploitation or even abuse (Couldry 2014). Banks and Potts (2010) found that in modding communities, co-creation is not explicitly coerced but has subtle types of social incentives that motivate the labor. Coercion may not always be obvious

(Reiheld and Gay 2019). Engaging in citizen science in a classroom setting can be pedagogically useful (Schrier 2017a, Mueller et al. 2012), but it can also result in students being compelled to participate and share data in coercive ways (Reiheld and Gay 2019). Even the rhetoric around citizen science and knowledge games as being part of one's civic duty – and using phrases like *contributing to the common good* or *being a good citizen* – is also problematic and coercive (Woolley et al. 2016).

Millburn and Wills (2021) provide an important humanistic perspective on knowledge games. They argue that the stories, myths, and tropes that many knowledge games rely on could be helping players to feel optimistic about solving important scientific problems, while also rehearsing and consenting to exploitative power dynamics and labor practices that serve institutions and corporate entities. Stories can help frame concepts and connect players emotionally, but they can also help reify problematic relationships. Stories can persuade, coerce, and obfuscate. How do we design games in ways that avoid these coercive relationships – and even help to undermine and subvert them?

How do we ensure that a socially-beneficial knowledge game is also ethically distributing power? Eleta et al. (2019) looked at the power relationships among the scientists and citizen scientists in environmental and biomedical projects, and provide a model for collective governance and shared decision-making. Grant et al. (2019) describe a participant-led research study, where participants helped with experimental design and data analysis. Hsu and Nourbakhsh (2020) argue that a bottom-up structure that empowers the local community can help to empower people and give them more control in policymaking and decision making, such as how to fix contaminated water wells. Avram et al. (2017) consider how sharing platforms, like games, could be designed with consideration to the ethics of care, and an obligation to build caring relationships among designers and participants. Finally, Clegg et al. (2020, 55) discuss ways to encourage concientización – or "the process of individuals and communities directing their own learning in nonhierarchical ways."

Design. How are Ethics Embedded in the Game's Design?

This section describes how the design of a game matters – and affects how biases are embedded and expressed through a game. How do we consider not only the intention behind the design, but also its impact?

Embedded Biases

Just like any research design, or any experience that is designed, all games are *biased* and embedded with particular values or cultural norms (Pannucci and Wilkins 2010, Schrier 2015, Schrier 2021). Biases do not have to be *negative* but are the outcomes of living in a particular cultural, social, or economical moment or place (Schrier 2016, Schrier 2019). They may relate to knowledge gaps, perspectives, or ways of thinking, or could stem from errors, incorrect data, or even structural issues, such as sexism or racism (Schrier 2021, Squire 2014, Schrier 2016, Benjamin 2019). Any platform, algorithm, artificially intelligent agent or designed system embeds biases, such as replicating the control and surveillance of Black and Brown bodies (Benjamin 2019, Noble 2018). In this literature review, articles considered inequities in relation to citizen science and knowledge games (Chesser et al. 2019, Pandya 2012, Fiske et al. 2019), but this area remains extremely under-researched.

Biases may be introduced at any time, and no research study or knowledge game is bias-free. Rather, designers must be able to communicate these biases and transparently evaluate how they manage and use them in their research (Pannucci and Wilkins 2010). Common biases in a knowledge game could involve self-selection bias (who plays the game), what types of data gets played in a game, which types of questions are privileged, how communities are represented in a game, and the level of skill in game playing or science that a player comes in with (e.g., lead-time bias). As more and more knowledge games incorporate AI, machine learning, and other techniques, we need to consider the ethical risks of how these are designed and applied, and how power is negotiated (Ceccaroni et al. 2019, Crawford 2021). Likewise, data is not neutral, it is also biased. Design – of a platform, a game, or an algorithm – is *not* objective (Gitelman and Jackson 2013, Allan and Redden 2017, Schrier 2021, Ceccaroni et al. 2019).

Games are cultural artifacts and systems that can be evaluated and reflected upon to determine the types of biases and values that they embed (Deng, Joshi, and Galliers 2016, Flanagan 2009, Flanagan and Nissenbaum 2014). Developers need to take a value-sensitive design approach (Friedman et al. 2017), and set clear value goals (in addition to design goals), continually reevaluate these goals, and reflect on how their design and values affect each other (Flanagan 2009, Flanagan et al. 2007, Schrier 2021, Schrier 2019). Deng et al. (2016) used a values sensitive design approach to reveal nine values shared by the microtask workers in Amazon's Mechanical Turk crowdsourcing platform, as well as ways in which the design of the platform both marginalized and empowered the participants.

We need to look at the *machinery* behind the game (Knorr-Cetina 1999) and evaluate the affordances, or functions and activities enabled or disabled by a particular game or project (Postigo 2014). The design of a game influences which questions get asked and how they get asked. For instance, how does the design limit or explore certain types of methodologies or epistemologies? Does it ensure equitable participation or exclude certain people? How does the game's design motivate players, and is it coercive in its invitation to keep playing (Campbell 2014)? How does the design of the game oppress or empower its participants? Does it punish or control certain types of participants (Benjamin 2019)? The game's design helps to determine what type of knowledge gets produced, how it gets produced, and what we will end up knowing.

Moreover, there is a lack of transparency into how games and their algorithms are designed (Allan and Redden 2017). Cooper et al. (2021) explain that projects need to be transparent about their research methods, processes, and goals, and provide the information needed so that the public can properly use and interpret any results of the research. Increasingly, projects are not just being designed by scientists, but also by technologists and designers (Bafeta et al. 2020). We need more critical perspectives from design studies, human-computer interaction, media studies, information sciences, and other related fields (Preece 2016, Lukyanenko 2020). Are citizen science and game communities engaging with and listening to each other?

Design and Impact

How do players engage with the design and impact of knowledge games? Results by Ponti et al. (2018) suggest that for many, having fun, competing with others, and being part of a community are all motivating factors, alongside wanting to build scientific knowledge, which also relates to findings by Tinati et al. (2016). But for other players and projects, fun is not the key motivator. Nov, Arazy and Anderson (2014) investigated three citizen science projects, including *Stardust@home* (2006), and found that participants were motivated to contribute due to the project's goals, how others may respond to their participation, and other extrinsic and intrinsic factors.

Farmers in an agricultural-related project were motivated by altruism or helping others, and the ability to share information and contribute to science (Beza et al. 2017).

Work by Preece (2016) suggests that some competitive game mechanics may not best support citizen science interactions, such as badges, leaderboards, and scores, and they may even deter participation. This could also be coupled with research by Lakomy et al. (2020) that suggests that men and younger people are motivated by extrinsic benefits or rewards (in a game this could include scores or trophies); whereas woman and older people were more driven by intrinsic rewards, like working on problems for the sake of their own interest (in a game, this could include connecting the game to one's own interests or a desire to volunteer).

Knowledge games, and their design, have an impact beyond the game. First, games are ethical, social, and cultural systems. They express values, involve players and designers who are ethical arbiters, and they interact with and affect other systems (Schrier 2019, Sicart 2009). Researchers are beginning to ask: what is the social and environmental impact of the creation of these types of games (Crawford 2021, Vohland et al. 2019)? Is the knowledge that is gained worth what is lost through its impact? Games may compel players to enter fragile ecological systems, which may lead to further destruction or harm, such as to trees or wildlife (Pocock et al. 2020, Palmer et al. 2020). Games may gather data from lower-income communities or Indigenous lands with good intentions, but they need to partner with them sensitively and inclusively to make valuable impact (Chesser et al. 2019).

We need to design for (and *with*) communities and audiences – and even crowdsource designs of games – in ways that may sometimes even supersede research needs (Preece 2016, Bowser 2016). The literature search revealed the use of terms like co-design, participatory design, and open prototyping (Sagarra et al. 2016). In particular, Sagarra et al. (2016, 10) cites the need for a dialogue "between the *matters of concern* raised by citizens and the *matters of fact* raised by scientists." Communities are not just targets; they are organic and dynamic, and we need to care for and with them (Franz and Murphy 2019, Avram et al. 2017).

Conclusion

In this article I have investigated scholarship related to the ethics of knowledge games. From a systematic literature review, five key ethical areas have emerged, including ones around data, the framing of games, accessibility, participation and power, and design (see a summary of the questions that emerged in table 1).

Researchers suggest a number of actions that designers can take to ensure ethical designs and uses of knowledge games. First, designers of knowledge games should think about how to mitigate inaccuracies and mischief in their game communities. Privacy issues are also important to consider. Researchers cite a number of frameworks to ensure participants are not harmed, as well as to enhance the transparency in how participants' game play is used and analyzed in and beyond the game.

Designers of knowledge games may also want to think about how biases are embedded in any game, and the accessibility and inclusiveness of a game's design. Are games designed with communities that they aim to support, and what is the impact of a games' design in terms of equity, as well as ethics. Designers should think about the cultural impact of their games, not just on the communities they aim to help, but also in how they shape (and are shaped by) culture. How might the framing of games as *fun* affect how they are used to evaluate serious topics? In addition, knowledge game designers should think about the relationship of the designer/researchers with the players/participants. Is this relationship equitable, or is it exploitative in any way? As boyd and Crawford (2012) recommend, researchers must keep asking themselves and each other about the ethics of how they use, manage, and collect data, and the broader implications of all aspects of their designs and their communities.

The ethics of knowledge games is an understudied area – it is also complex, messy, and indeterminate and requires perspectives from different disciplines, constituents, and the public. We need to invite policymakers, practitioners, ethicists, designers, humanists, and researchers of all types to design and critically evaluate these games. Studying them may even help to reveal and problematize that which has been obscured – the inequitable institution of knowledge production, and the complicated relationship among society, researchers, and the public.

Area of Ethical Concern	Main Question	Sub-Questions
Data	**How is data collected, managed, analyzed, manipulated, and used?**	**What types of data gets vetted and trusted?**
		Who interprets, collects, and vets data?
		Who designs how the data is invited, stored, and vetted?
		How are people being informed around how their data is being used in a game?
		How is informed consent gained and used?
		How is privacy limited or supported?

		How do we inform players enough about how their contributions will be used, communicated, and secured?
		Which methodologies and tools are used to interpret data?
		How is data being interpreted and shaped?
Game Context	**How do games as games affect the ethics of knowledge production?**	**What happens to data and knowledge when it is played through a game?**
		How does the game re-frame how knowledge is communicated, validated and accepted?
		How does fun and leisure factor into knowledge production?
		How are serious topics and questions being integrated and translated to games?
Accessibility	**Is the game accessible and equitable in participation?**	**How do we recruit and maintain a representative and appropriate sample?**
		How do we ensure equitable access to contributions, tools, skills, and social capital?
		How do we ensure inclusive and culturally sensitive practices when engaging with communities?
		How do we enable equitable control and share power over data and results?
Power and participation	**How is power negotiated and how are players valued?**	**Are players compensated or given benefits for their labor?**
		Is the work exploitative, alienating or immiserating?
		Is the work or labor given freely, voluntarily and without coercion?
		How does the fun of the game affect its ability to exploit or coerce?
		How do we balance societal and research benefits with individual risks?
		How do we best care for our players as workers?

Design	How are ethics embedded in the game's design?	How are biases are embedded in the game's design?
		How are we communicating our biases and how transparent are we?
		How do we consciously evaluate the values embedded in our game and its surrounding communities?
		How does our design limit or enable participation?
		How does our design empower or oppress, support or coerce our communities?
		How does our design determine what type of knowledge gets produced, how it gets produced, and what we will end up knowing?
		What are the environmental impacts of our designs? How sustainable is our creation?

Table 1. A table listing ethics-related questions to ask. This list is not exhaustive.

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