

## Conceptualizing Critical Game Design as a Method to Engage Youth with Critical STEM

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**Abstract:** This conceptual paper examines the educational affordances of critical design as a pedagogical tool for youth engagement in critical STEM learning. We conceptualize a critical design approach for using game design as a medium for critical STEM learning. First, we define critical design for the purpose of the paper; second, we discuss why critical design is important for STEM learning, and third we address ways in which critical design approaches might be applied through critical game design. We propose that using critical game design to engage youth creates educational possibilities for thinking and communicating about the social, political, ethical, and historical dimensions of STEM.

### Introduction

In this conceptual paper, we draw upon work in critical design, critical STEM learning, and game design to examine the educational affordances of critical game design to engage youth with fundamental STEM issues (e.g., ethics, ideologies, history, biases within STEM). Through these three lenses, we expand thinking about the potential of games as media to support design thinking and STEM literacies (e.g., Parekh et al., 2019) while attending explicitly to the social, cultural, ethical, and political dimensions of design. We view this approach as an opportunity to support transdisciplinary STEM learning (e.g., Sengupta-Irving & Vossoughi, 2019; Takeuchi et al., 2020), engage learners in communicating STEM issues through critical game design in a participatory manner (e.g., Literat et al., 2020), and position learners with greater agency through their design process.

We view design as a non-linear, dynamic, and complex process that involves decision making, thinking, and doing shaped by ideologies and values of designers, practitioners (e.g., teachers, stakeholders), researchers, and participants in the design process (Mawasi et al., 2020). Attending explicitly to social, cultural, ethical, and political ideologies embedded in design processes and outcomes (including artifacts, systems, and knowledge) is crucial for more equitable, inclusive, and transformative STEM learning experiences and practices (Barab et al., 2007; Bang & Vossoughi, 2016; Medin & Bang, 2014). This attention challenges the presumed social and political neutrality of design thinking models and prompts learners to explore the values, interests, and standpoints instantiated in and reinforced by designed objects and the larger practices or systems in which they are used (Barab et al., 2007; Mawasi et al., 2020). Such examination can engage learners in critical design efforts that question existing designs, enhance learners' experience of agency in design (e.g. Aguilera et al., 2020), and expand their critical interpretive and meaning-making capacities (The New London Group, 1996). Recently scholars have challenged the cultural, racial, and economic agenda of dominant forms of STEM education (Vossoughi & Vakil, 2018) and called for STEM education in which "liberatory politics and deep disciplinary learning co-exist and co-develop" (Vakil & Ayers, 2019, p. 455). In this paper, we join this conversation by providing speculative reconfigurings of how critical game design as a learning activity might engage learners in critical STEM.

Game design has multiple affordances for engaging learners in critical reflection on dominant design goals, processes, values, and assumptions (Flanagan & Nissenbaum, 2014). Among these affordances are the interactive and systemic nature of games; games engage players through goals and actions that comprise "figured worlds" reflecting culturally and socially contexts of meaning (Holland et al., 2001). Prompting learners to think about values reinforced by their own and others' design artifacts can help them identify and evaluate the ideologies these designs reflect (Thumlert et al., 2018). While Flanagan and Nissenbaum (2014) and other design educators offer strategies to prompt designers' reflection on values in games, such critical approaches have rarely been applied specifically to game design in STEM. Additionally, educational games that expose learners to societal and ethical issues within STEM fields typically are not designed by learners, rather, they are used as an educational tool to teach STEM related concepts and practices (e.g., Barab et al., 2010).

Building on such work, we first define "critical design," drawing on concepts and strategies from several different fields. Then we discuss critical game design as an opportunity to engage youth in STEM learning that enables them to actively engage with and challenge restrictive and inequitable ideologies and practices.

## Critical design across disciplines

Various disciplines offer somewhat different conceptions of critical design that inform our approach to critical game design in STEM education. Here we briefly identify key ideas from industrial design, human-computer interaction, game design, and the learning sciences.

### Critical design in industrial design

Within industrial design (also known as product design), critical design arose as a means to “challenge how people think about everyday life” (Dunne & Raby, 2013, p. 45), particularly about the nature and role of designed objects, and to encourage people to imagine different possibilities (Dunne & Raby, 2013). Malpass (2017) describes critical design practice within the industrial design field as an approach that aims to use design as a medium of inquiry for facilitating “ways of knowing, exploring, projecting, and understanding the relationship between users, objects, and the systems that they exist in” (p.43). The goal of critical design is not a new or more desirable product, but rather to prompt questions about the values a product reflects, the assumptions it operates within, and the ideologies embedded and enacted within design methods, tactics, and strategies (Dunne & Raby, 2013; Malpass, 2017). For instance, Malpass (2017) describes how critical designers employ satiric devices such as humor and irony to provoke trenchant critiques of hegemonic values associated with production and consumption. However, as Dunne and Raby state, critical design is not intended to be entertainment, nor a form of art, but a means of “making abstract issues tangible” particularly as these issues are instantiated in everyday objects.

### Critical design in human computer interaction

Scholars such as Bardzell and Bardzell (2014) have extended the concept of critical design to the field of Human-Computer Interaction (HCI). Building on Dunne and Raby’s view of critical design as means of changing perspectives and prompting new insights, Bardzell and Barzell define critical design as “a research through design methodology that foregrounds the ethics of design practice, reveals potentially hidden agendas and values, and explores alternative design values.” (p. 3297). The authors provide a more detailed and multifaceted conception of criticality, drawing on ideas from critical theory as well as metacriticism. They also argue for a broader conceptualization of what “counts” as critical design, including some forms of art as well as designs that may not be intentionally subversive but ultimately raise awareness of underlying ideologies and biases in design processes and goals. Lastly, they critique Dunne and Ray’s distinction between affirmative and critical design, noting that any given design can both affirm and critique various aspects of the status quo.

### Critical design in games design

In his classic essay on toys, Roland Barthes (2012/1957) describes how children’s toys, as representations of the adult world, reflect broader social and political ideologies and structures that communicate appropriate and desirable ways of being and knowing. Even the use of cheap plastic for many toys reinforces a disconnection between human designs and the natural world. Barthes’ view is illustrative of the work of scholars who study the broader social and political dimensions of play. Scholars in the field of game studies have addressed the implications of play across different levels of modalities (systems, procedures, visuals, symbols etc.) through analysis of games, game mechanics, and game design (e.g., Bogost, 2010; Salen & Zimmerman, 2004). Games as a medium in this sense can take different forms, digital or analog. A particular emphasis has been on how game rules and processes - the “procedural rhetoric” of games (Aguilera et al., 2020; Bogost, 2010; Salen & Zimmerman, 2004) - reflect beliefs about how the world works.

Critical game design includes approaches that prompt game designers to reflect on and challenge the values and assumptions that may influence their own design processes (Flanagan & Nissenbaum, 2014) as well as the creation of games with the deliberate intent of provoking critical thinking among players about the values, perspectives, and ideologies a game reflects (e.g., Cassar, 2013). In this sense, game design becomes not the creation of entertainment but a form of activist critique and advocacy for a social issue (e.g., Games for Change Student Challenge). Critical game design can also engage players in critically examining game mechanics, narratives, and representations. This perspective illustrates how play and procedurality within games mediate meaning making that can reproduce or challenge ideological systems and values.

### Critical participatory design in learning sciences

The growing attention in the learning sciences to social, political, and ethical dimensions of learning has contributed to interest in participatory design approaches (Bang & Vossoughi, 2016). This includes the use of participatory research methods that shift power dynamics between researchers and participants and leverage diverse ways of knowing (Mawasi et al., 2020; Vakil et al., 2016). These methods might be considered critical in the broad sense of challenging dominant assumptions about whose voice and knowledge “counts” in the research

process. However, some researchers have adopted more overtly activist strategies that involve participants in identifying questions, designing research approaches and identifying their desired futures or educational possibilities (e.g., Bang & Vossoughi, 2016; Tzou, et al., 2019). For example, in their participatory design research approach Bang & Vossoughi (2016) account for critical historicity, power, and relational dynamics within design methods themselves, creating opportunities to transform existing practices towards transformative educational change, rather than reproducing inequities as an outcome of design processes. The authors invite us to consider what they call axiological innovation, that is, thinking about meaning-making mediated by aesthetics, theories, practices, values, and ethics in design processes (Bang & Vossoughi, 2016). Another example is critical design ethnography described by Barab et al. (2007) as an approach that explicitly addresses power issues and agendas within the design process and its outcomes.

### **Critical game design: An approach to engage learners with critical STEM**

A commonality across previous work on critical design is explicit attention to how dominant design processes, artifacts, and consequences reflect and reinforce social, political, cultural, and historical agendas. Design is re-imagined as a means of calling into question these agendas. Engaging learners with such critical design approaches in STEM may contribute to broader efforts to recruit marginalized populations to STEM, develop more inclusive and ethical design practices, and challenge dominant ideological dimensions of STEM education.

STEM education continues to be dominated by Western ideologies of scientific knowledge, practices, and excellence (Medin & Bang, 2014). Critical STEM education has been proposed as a way to help students think critically about their own engagement with STEM in school and in daily life, understand the historical, political and ethical dimensions of STEM, and see the potential of STEM to contribute to a more just and equitable society (e.g., Sengupta-Irving & Vossoughi, 2019; Takeuchi et al., 2020). Building on Freirian notions of critical pedagogy, scholars propose that critical STEM education should explore how normative discourses in STEM shape the construction of STEM knowledge and strategies, and position learners to challenge biases and inequities by cultivating their ability to create and use new tools and methods for knowledge creation and representation (Vakil, 2014; Vossoughi & Gutiérrez, 2016). We propose that design approaches such as critical game design can play a central role in critical STEM education as a means of engaging learners not only in critique but in creating artifacts and experiences that offer new forms of engaging with STEM.

Our own interest in critical game design grew out of our previous experience with using game design to engage young people in design thinking. In this earlier work, we hoped to engage participants in designing games that addressed social issues of relevance to their communities and that were personally meaningful. We adopted a popular model of design thinking as a framework. In analyzing the participants' design process and game artifacts, we discovered instances of "spontaneous" critical reflection. For example, in creating a game about water pollution, participants argued over whether the game should be competitive or collaborative, and questioned assumptions that individual actions alone might be effective in addressing this problem. In another game focused on the problem of agricultural pollution, the youth designers rewarded certain game actions with food from Taco Bell, an ironic means of illustrating our often unconscious participation in the very systems that we critique. Such examples inspired us to seek ways to more deliberately support youth engagement in critical game design.

Our conception of critical game design is still evolving, but we offer some conjectures about this approach to critical STEM education. Critical game design as a pedagogical approach may and should encompass a variety of experiences, topics, and goals. In contrast to models of design thinking that offer simplified steps and toolkits, the process of critical game design can't be reduced to a recipe. Indeed, we anticipate that a critical approach will prompt participants to question some common design techniques. They might question popular strategies for "empathizing" with potential users, or observe how power relationships are implicitly reinforced in relationships between game designers and players. Critical game design does not have to consist of designing entire games; learners can be introduced to ideological aspects of games through playing and critiquing existing games with a STEM focus. Emphasis might be placed not only on how STEM is represented through narrative or visuals, but also how game play itself reinforces values such as competition or collaboration. Learners can redesign existing games as a means of challenging or re-imagining existing STEM practices, goals, and ideologies. They can design games intended to provoke critical reflection on STEM-related issues. There are a small but growing number of games created for social critique that may serve as inspiration. Even a game design challenge without an overtly "critical" purpose can be a starting point for critical reflection. At the same time, designing games should be integrated with other forms of STEM education to cultivate learners' understanding of fundamental STEM concepts and tools. Ideally we view this as a reciprocal process; as learners grapple with representing STEM issues through games, they may come to a deeper understanding of, for example, current theories about environmental systems, or the nature of scientific models. Game design offers considerable potential as a context for learning; we hope to provoke greater attention to its *critical* potential as well.

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