

“I’m a Solo Developer but AI is My New Ill-Informed Co-Worker”: Envisioning and Designing Generative AI to Support Indie Game Development

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Indie game developers are often defined as game developers who are typically not employed by or affiliated with tech giants or large gaming companies/publishers. Although people may decide to “go indie” for various purposes, indie game development has become a crucial part of the global gaming culture. However, this community is now facing unprecedented tensions as generative AI technologies are shifting how games can be designed, produced, and experienced. Through a qualitative analysis of 3,091 online posts and comments from subreddits and Facebook groups for indie game developers, we offer an in-depth investigation of how indie game developers perceive and envision the multifaceted role of generative AI in their creative practices. Our empirical investigation reveals that generative AI both promotes and harms indie game developers’ endeavors to innovate the traditional game production model, which further influences the nature and workflow of creativity in game development. We also propose three principles for designing future generative AI technologies to improve indie developers’ work while mitigating potential risks, harm, and negative impacts of AI. We hope that this study can help design and develop future generative AI technologies to foster and sustain more democratic and inclusive practices in game development rather than replacing human creators.

CCS Concepts: • **Human-centered computing** → **Empirical studies in collaborative and social computing**.

Additional Key Words and Phrases: Generative AI, Creativity, Game Development, Indie Game Development

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1 INTRODUCTION

Independent [indie] games are broadly described as games that are consciously created outside of the production and distribution structures of the mainstream game companies [38]. Therefore, indie game developers are often defined as game developers who are typically not employed by or affiliated with tech giants or large gaming companies/publishers [11, 12, 14, 17, 22, 34, 42, 51, 53, 57, 59, 62, 72, 73]. Usually, people decide to “go indie” for various purposes and goals, ranging from just making games for fun to learning necessary skills to eventually enter the mainstream gaming industry [22, 57]. For example, some indie game developers and studios are primarily **entrepreneurship and profit-driven**, which reflects their endeavors to foster new forms of funding, business and revenue model, and work atmospheres in the gaming industry [11–13, 17, 17, 21, 42, 51, 57, 72]. Meanwhile, a subset of **non-profit-driven** indie developers are inspired by the increasingly open

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and participatory dynamics in today's game production. They tend to advocate an activist agenda to collectively promote key indie values of sharing, openness, and creativity rather than merely focusing on revenues and financial gains in game development [11–13, 25, 26, 29, 62, 65, 71].

Regardless of indie game developers' various goals, motivations, and purposes (e.g., profit-driven or non-profit-driven), taken together, indie game development is now a crucial part of the global gaming culture [11, 12, 14, 17, 22, 34, 42, 51, 53, 57, 59, 62, 72, 73]. However, more recently, this community is facing unprecedented tensions as various **generative Artificial Intelligence (AI)** technologies have been increasingly used in game development. This new trend is significantly shifting the trajectory of the gaming industry by affecting how games can be designed, produced, and experienced. For example, the incorporation of generative AI in various game development tools and processes (e.g., Unity Muse and Unity Sentis [69]) is considered a potential risk to many indie game developers' creative practices and careers. It has also been reported that people can build an Angry Birds style game solely through using generative AI tools including ChatGPT, DALL-E, and Midjourney to produce its assets and code [16]. In this case, although the very essence that makes Angry Birds a highly successful game (e.g., the intuitive physics simulation and the satisfaction of efficient destruction) cannot be generated by AI, how AI is able to replicate the assets and code of existing successful games raises important concerns about the future of small-scale indie games [16].

We thus argue that an in-depth investigation of how indie game developers perceive and envision the multifaceted role of generative AI in their efforts to innovate game development and production is critically needed. On the one hand, this community differs from traditional creative workforces that have been extensively studied in HCI research on generative AI and creativity (e.g., musicians, artists, designers, or novelists). On the other hand, compared to the mainstreaming gaming industry (e.g., AAA studios), this community may face more frequent and severe challenges brought about by emerging generative AI technologies due to their special focus on the creative, cultural and artistic values of games and their relatively limited access to financial and technical resources for game production [11–13, 17, 21, 22, 50, 51, 57].

In this paper, we report our findings of a qualitative analysis [6] of 3,091 online posts and comments from subreddits and Facebook groups for indie game developers regarding their reflections and envisions of leveraging generative AI to support their creative practices. In doing so, we explore the following two research questions:

RQ1: What are the perceived novel opportunities and urgent risks of generative AI for indie game developers' efforts to innovate game development and production?

RQ2: How can we design future generative AI technologies to enhance such opportunities and mitigate risks to better support these developers' efforts?

Our work makes several contributions to HCI and games research. First, we provide a much-needed empirical investigation of the increasingly complicated roles of generative AI in both supporting and harming indie game developers' endeavors to innovate the traditional game production model. Our work thus sheds light on generative AI's potential to actively affect the nature and workflow of creativity in the game development sphere, which is understudied in prior works on generative AI and creativity. As the indie game development community is often considered an alternative to the mainstream gaming industry, these insights can further inform future research on better understanding how generative AI may both innovate and threaten the future trajectory of new creative workforces in game development. Second, grounded in viewpoints and recommendations collected from indie game developers' online discussions, we propose three high-level principles for designing future generative AI technologies to facilitate and improve these game developers' quality of work while mitigating potential risks, harm, and negative impacts of AI. We

hope that our work offers a proactive approach to envision the future of generative AI in supporting rather than harming these creative communities.

2 RELATED WORKS

2.1 The Emerging Role of Generative AI in Creative Work and Game Development

Artificial Intelligence (AI) has become the core driver of innovation in emerging technologies [40] and is increasingly being used in various work practices, such as healthcare [5], manufacturing [10], and education [70]. More recently, there is also a growing trend of using AI systems for creative work, such as producing music, texts, arts, and designs that are similar to what humans could create [39, 63, 67]. These AI systems, which are typically termed **generative AI**, are often trained using large datasets and can generate new content based on learned and reproduced patterns from the training datasets [8]. As such, a growing body of work has begun to explore how to leverage generative AI systems (e.g., ChatGPT [48] and Midjourney [46]) to support various creative practices and workflows, which presents new opportunities as well as potential risks and harm. Grounded in such research, below we summarize three main highlights regarding generative AI's new role in creative work.

First, generative AI serves as a creativity support tool to facilitate almost every aspect of creative workflows. Existing works have extensively explored how creative professionals, including musicians, visual artists, designers, and writers, perceive and use generative AI systems at various stages of their creative practices for different purposes. For example, AI music models can be used to help musicians, especially novice musicians, co-create new musical phrases both with AI and with other human musicians to facilitate the social music composition process [39, 63]. Likewise, in the area of arts and design, generative AI systems have been used to augment human's creative efforts in varied ways, ranging from rapidly creating ideas and visual concepts, automatic generation of images from words (e.g., sketching), expanding creator's ideas based on prompts, combining irrelevant design concepts in reasonable ways, to early prototyping [8, 27, 32, 36, 67]. Efforts have also been made to design and develop advanced AI systems to help writers and novelists create compelling narratives. Examples include automatic story generation based on image sequences [24], child-AI collaborative drawing systems for creative visual storytelling [74], and using large language models to support creative human-AI co-writing [18, 20].

Second, despite these benefits, generative AI is dramatically shaping the notion of creativity and may even harm human's creative practices. Many creative professionals have voiced their concerns that generative AI triggers debates and controversies regarding what defines creativity as a unique human nature and how humans should approach AI in their creative practices [27, 36, 58]. Some seem to argue that generative AI should be considered a non-human co-performer in creative practices [67] while others are worried that AI may replace human creators with low quality or incoherent output [8, 27, 39, 67] and lead to information overload [8, 39]. Indeed, AI-supported creative works are often perceived negatively compared to those created by humans only [54]. Therefore, researchers have highlighted several potential directions to mitigate generative AI's potential risks and harm for creative work, such as: making AI be human's partner in the creative process by treating AI as a nanny, a pen-pal, a coach, and/or a colleague [41]; actively engaging creative professionals in developing more participatory generative AI [27]; and further promoting human-AI collaboration to advocate the new human-AI co-creation model [7, 15, 18–20, 74].

Third and most related to our work, how generative AI can be used and envisioned in game design and development, which is also a key player in the creative industry, receives relatively less research attention. Only a small body of research has begun to investigate the emerging role of generative AI in creative programming and game design/development. For example,

Jonsson and Tholander's work explores how generative AI can be used to translate natural language to computer code, which not only lowers thresholds for learning programming but also encourages learners to further reflect upon the programming process [30, 66]. Sun et al.'s work echoes this understanding and elaborates generative AI's role in code translation and code autocompletion beyond just natural language to code [64]. These human-AI co-coding processes seem to introduce interesting questions regarding AI as a tool for learning to code versus as a co-participant in the creative programming process [30, 66]. Moving to the area of game design and development, most existing works focus on leveraging automated content creation and AI-assisted design processes to facilitate game production [3, 9, 23, 33, 37, 52]. Such efforts have led to several mixed-initiative systems, such as the Evolutionary Dungeon Designer, to promote the collaboration between human game designers and AI to advance procedural content generation in game development [3, 4, 33]. Researchers have also explored new ways for game designers to generate personalized game content through effective human-AI co-creative tools [9, 23, 37, 52]. Among them, Liapis et al. propose designer modeling for automatically applying a game designer's preferences and goals in game development, which makes their creative practices more personalized and effective [37]. Partlan et al. further categorize and analyze game AI designers' workflows and expectations for computational co-creativity tools to help achieve their game design goals [52]. Additionally, Dang et al. introduce a prompt-based generative AI tool (i.e., WorldSmith) to help novice game developers visualize and modify their game worlds using multimodal input [9]. And Guzdial et al. dive into how game developers may perceive an AI-driven game level editor as friend, collaborator, student, or manager based on their own artistic style and their willingness to adapt to the AI level editor [23].

Taken together, this small body of existing literature has highlighted several important principles for involving AI and computer-assisted creative tools in game design and development, such as *respect designer control, respect the creative process, and respect existing work processes* [33, 52]. These works have also warned that while AI introduces novel opportunities to game design and development, it challenges traditional creative norms in how we create and experience games as well. In this sense, how generative AI systems can be designed to support, rather than suppress, human creativity in game development is a critically needed research agenda that may significantly shape the future trajectory of the gaming industry. Therefore, we are particularly motivated to focus on how indie game development perceive and envision generative AI due to this community's continuous efforts to innovate the traditional game production model.

2.2 The Importance of Investigating Indie Game Developers' Efforts in the Age of Generative AI

The indie game development community is playing an increasingly important role in understanding and approaching the evolving gaming culture and the game production pipeline today. As such, it has led to a growing body of research in HCI and game studies. For example, prior works have explored various indie-related topics, including: what motivates game developers to go "indie" [22, 57]; indie game developers' struggles with self-exploitation [73] and their unique organizational and managerial practices [53, 72]; and how indie game developers define independence and autonomy in their creative practices [17, 42], among others. Collectively, these works have highlighted indie game development as a complex and highly heterogeneous community, which has attracted developers of all levels and skills with various purposes, goals, and motivations, such as: profit-driven or non-profit-driven; entrepreneurship-oriented or interest/hobby-oriented; and activist or non-activist [14, 22, 42, 59, 62, 72].

Despite being a highly heterogeneous community, indie game developers largely view their games as a form of artistic and cultural expression of their craftsmanship, which sets them apart from the

mainstream gaming companies that prioritize sophisticated, profitable software products (e.g., triple-A level games) [11–13, 17, 21, 22, 51, 57]. For these developers, the mainstream gaming industry, particularly in North America, is notorious for its highly intense and stressful work practices: long hours, looming deadlines, hard-core workers, big money payouts alongside tremendous losses [47], and rampant sexism (e.g., Gamergate). In contrast, the indie game culture may offer an alternative game production model that not only emphasizes the artistic and cultural values of digital games but also fosters new forms of funding, business and revenue structure, and work atmosphere in the gaming industry [11, 25]. However, existing works have also pointed out that this view of indie game development for innovating the established, traditional game production model can be over-idealistic [28, 34, 42, 53, 73]. In fact, these developers are facing increasing conflicts between their small team style and the structure and power dynamics within contemporary gaming culture [13, 17] and growing tensions emerging in the exploitative and precarious nature of their work and unsustainable production model [13, 73]. In particular, as new technological advances, such as generative AI, have begun to play an impactful role in creative work, including game development, we believe that the indie game development community may face more unprecedented tensions and challenges that urgently require further investigation for two reasons.

First, as mentioned above, indie game development appears to significantly differ from the mainstream gaming industry, which often consists of expert game developers and focuses on sophisticated, large-scale products [11–13, 17, 21, 22, 51, 57]. Indeed, these developers tend to form much smaller teams with various levels of skills and experiences and work on smaller-scale projects than large triple-A games [11–14, 17, 21, 22, 51, 57]. Therefore, they are well known for actively leveraging various online platforms (e.g., social media, online forums, and live streaming) for computer-mediated collaboration, collective learning, social support, and knowledge sharing to build a sense of community [11–14, 17, 21, 22, 35, 51, 57]. In this sense, this community differs from traditional creative workforces that have been extensively studied in HCI research on generative AI and creativity, such as musicians, artists, designers, and novelists, because it offers alternative production and distribution structures in the tech economy [11–13, 17, 17, 21, 42, 51, 57, 72].

Second, prior HCI research has highlighted that indie game developers are facing several challenges regarding labor, capital, and production in their creative practices [12, 13, 17, 31, 42, 57, 60]. As a result, engaging in indie game development can evolve into a severe personal burden for some developers, making their game development process a lonely and emotionally draining journey [13]. Therefore, compared to the mainstream gaming industry, indie game developers already suffer from their limited access to much needed social, technological, and financial resources for game development. This may make them face even more severe challenges brought about by emerging generative AI technologies. Steam, one of the primary platforms for publishing and distributing indie games, announced that games with AI-generated content will not be allowed on the platform [56], before backtracking and requiring extensive self-disclosure from game developers of instances of AI-generated content that does not infringe on copyrights [61]. This thus leads to tensions and confusion surrounding how and to what degree generative AI can be used to support rather than harm indie game development.

In this sense, how, if at all, generative AI technologies both further magnify these already identified risks for indie game developers and provide potential novel opportunities to help mitigate these risks should become important considerations for HCI and games researchers. This open space motivates us to explore (1) the perceived novel opportunities and urgent risks of generative AI for indie game developers' efforts to innovate game development and production (**RQ1**); and (2) how to design future AI technologies to better support, rather than harm, these developers' efforts (**RQ2**).

3 METHODS

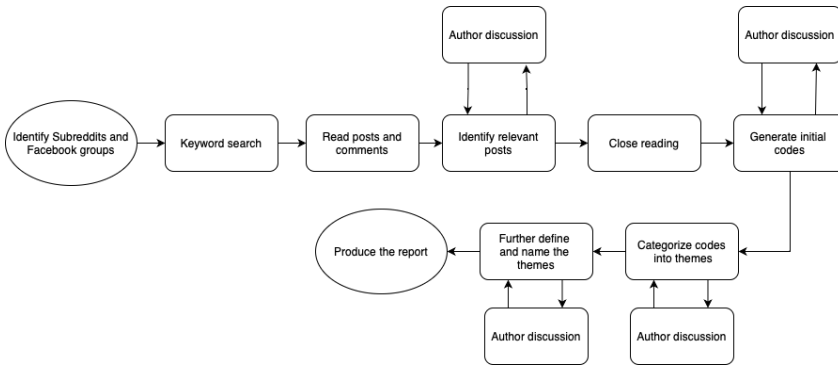


Fig. 1. Overview of data collection and analysis process in this study

Data Collection. We collected online threads including posts and comments that discuss the intersection of indie game development and generative AI (see Figure 1). Specifically, we collected such data from Reddit and Facebook groups due to their significant number of members, popularity, and impact within the indie game development community. We especially selected two subreddits that are most popular among indie game developers, *r/gamedevs* with 1.3 million members and *r/indiegames* with 183 thousand members. We also joined several popular Facebook groups for indie game developers, such as Indie Game Devs with 61,271 members and Indie Game Developers IGD with 141 thousand members. All of these platforms allow members to ask questions about all possible avenues of indie game development, including marketing, creating art, and coding, which provides us with a unique space to understand the impacts of AI on multiple aspects of indie game developers' creative process.

To collect data, we used keyword searches¹ on these online communities to collect indie game developers' self-reports regarding their various perceptions of AI's new role in their creative practices. We then comprehensively reviewed the retrieved online posts and comments and filtered out conversations that were not about generative AI (e.g., a post about how to program an AI NPC in their game) or not relevant to indie game development (e.g., a post about how a developer used AI for non-game-development purposes such as writing a personal email). As a result, a total of 3,091 posts and comments were used for further analysis. Our collected posts and comments ranged from August 2022 to January 2024. We believe that this is an appropriate timeframe for conversations surrounding AI's role in indie game development because most of the popular generative AI models were released during this time. For example, Midjourney was released in July 2022 [46], DALLE-2 in September 2022 [49], and ChatGPT in November 2022 [48]. Additionally, despite using public Facebook and Reddit data, we removed any possibly identifiable information from the dataset (e.g., usernames and location) to protect indie developers' privacy.

Data Analysis. We then adopted a thematic analysis approach [6] to conduct an in-depth inductive qualitative analysis of the collected data (see Figure 1). As we focus on indie game developers' own perceptions of using generative AI in their creative practices, a qualitative approach is appropriate for this study because qualitative methodologies are well-suited for investigating questions about "how people interpret their experiences, how they construct their worlds, and

¹The full list of keywords used for search includes: *AI, artificial intelligence, indie and AI, generative AI, AI art, AI Generated, Midjourney, ChatGPT, DALLE, Copilot.*

what meaning they attribute to their experiences" [45]. Based on McDonald et al.'s guidelines for defining reliability in qualitative analysis in CSCW and HCI practice, our analytical procedures focused on eventually yielding concepts and themes (recurrent topics or meanings that represent a phenomena) rather than agreement [44]. According to McDonald et al, even if coders agreed on codes, they may interpret the underlying meaning of those codes differently [44]. Therefore, we did not seek inter-rater reliability in our analysis but endeavored to identify recurring themes of interest, detect relationships and connections among them, and formulate them into clusters of more complex and broader themes [44].

Following Braun and Clarke's detailed guide to conduct thematic analysis [6], we analyzed all collected data in the following steps. First, we *familiarized ourselves with the data* [6]. The first author closely read through the collected data line by line to identify pieces of information that were relevant to the research question and to acquire a sense of the overall picture regarding indie game developers' various perceptions of generative AI in their creative practices. Second, we *generated initial codes and searched for themes* [6]. The first author assigned preliminary codes to identified pieces of information, combined codes, eliminated redundant codes, and categorized codes into thematic topics related to the research questions. Third, we *reviewed, defined, and named themes* [6]. Both authors continued to discuss, integrate, refine themes and subthemes, and name the final set of themes. At this stage, both authors considered themes across the entire data set and identified the "essence" of what each theme is about. Lastly, we *produced the report* [6]. Both authors discussed selecting the most compelling quotes as examples and drafted the structure of the findings in a logical way. The goal of this phase was to create a narrative structure where all findings flowed naturally and coherently. Figure 1 also summarizes our data collection and analysis process in this study.

4 FINDINGS

Overall, our data shows that the indie game community indeed has adopted various generative AI technologies in their creative practices. For example, these developers posted about using tools like ChatGPT and GitHub Copilot for coding tasks to streamline their development process. Some even mentioned using ChatGPT for crafting the storyline of their game and conceptualizing game ideas. Others described using generative AI to create artworks for their games, such as using DALL-E-2, Midjourney, and Adobe Firefly to generate character design, create the gaming environments, and produce concept art and game design prototypes. Additionally, AI voice generators have been used to create characters' voices, game narration, and soundtracks (e.g., Riffusion and Audiostream). These diverse applications thus underscore the urgent need to unpack the multifaceted role generative AI has begun to play in the indie game development community.

In addressing this concern, our findings have revealed how indie game developers perceive both opportunities and potential harm and risks of generative AI for their game development practices (**Section 4.1**). We then identify indie game developers' envisions for designing future generative AI systems to mitigate these risks and harm while maximizing the identified promising opportunities to support their creative practices (**Section 4.2**). It is also important to note that in line with well established arguments against reporting qualitative data numerically (e.g., [43]), when reporting our findings, we focused on the actual themes we identified across the full dataset rather than a numerical accounting of the frequency of certain codes. The main reason is that quantifying qualitative findings can be misleading, as "[n]umbers can lead to the inference (by either the researcher or the audience) of greater generality for the conclusions than is justified, by slighting the specific context within which this conclusion is drawn" [43]. Therefore, rather than attempting to quantify our qualitative data, Table 1 provides a summary of our key findings along

with percentages of posts that were categorized as certain themes to help capture the overall trends emerging in our data.

AI's Opportunities for Indie Game Developers (RQ1)	AI's Risks for Indie Game Developers (RQ1)	Developers' Recommendations for Future AI (RQ2)
1. Generative AI supports more focused and cost-effective game creation (9.7% of posts)	Career Growth Risk: Reduces the need for employing humans in indie game development and even in the larger gaming industry (9.3% of posts)	Establishing developer-artist-AI collaboration to address Career Growth Risk (9.2% of posts)
2. Generative AI helps idea and content generation to jumpstart development and creation (7.9% of posts)	Creativity Risk: Inability to create entirely new content and unable to maintain consistency in style (10.1% of posts)	Building AI models that reflect unique personalized artistic styles to address both Intellectual Ownership Challenge and Creativity Challenge (6.9% of posts)
3. Generative AI tools may motivate and allow more people to participate in indie game development and make it more accessible (6.2% of posts)	Intellectual Ownership Risk: Using AI-generated game assets may cause copyright infringement and legal issues for indie developers (12.5% of posts)	Building AI models that reflect unique personalized artistic styles to address both Intellectual Ownership Challenge and Creativity Challenge (6.9% of posts)
4. Indie game developers who usually work alone or only with a small team can use generative AI as a co-worker for immediate insights, feedback, and suggestions (8.4% of posts)	Personal Investment Risk: The process of training generative AI models as a co-worker who can meet indie developers' specific needs is time-consuming (8.8% of posts)	Adjusting the focus of AI to various skill and experience levels to address Personal Investment Challenge (7.9% of posts)

Table 1. Summary of key findings

4.1 Perceived Opportunities and Risks of Generative AI for Indie Game Developers

As shown in Table 1, Indie game developers' online discussions collectively highlight four ways in which generative AI could simultaneously provide novel opportunities and urgent risks to their endeavors to innovate game development.

4.1.1 Generative AI Supports More Focused and Cost-Effective Game Creation but Poses Career Growth Risk for Small-Scale Indie Teams. First, many indie developers note that a significant opportunity of integrating various generative AI technologies in their creative practices is to **help small-scale indie teams to streamline their development processes, resulting in more focused and cost-effective game creation** (9.7% of posts). This shift is seen as a game-changer because it has the potential to enable small indie studios to compete with their larger counterparts, who traditionally possess greater financial, technological, and human resources for advanced game development.

Indeed, as one developer explains, "*AI can help us with every kind of work that we think it's exhausting or tedious. In this way, AI works for us and we do the fun parts of the work.*" Here this post highlights how generative AI can provide indie developers with the capability to automate mundane and repetitive tasks that would otherwise consume significant manual effort. For developers like this, one main strength of generative AI is to streamline the development process and shoulder the burden of conducting "*exhausting or tedious*" tasks in game development. This thus has the potential to not only make indie game development efficient but "*fun.*" Others also add,

"It's just faster and cheaper. You can't compete if you're not cutting down production costs."

"AI art is incredible for a small team or a solo dev like me, who would never have the time nor the money to hire a concept artist. It lets us realize our vision more closely."

For these developers, leveraging generative AI technologies significantly accelerates their game production while simultaneously reducing the financial burden, which is considered a main challenge for indie developers in prior works [12, 13, 17, 21, 57]. This is especially valuable for small indie teams who are unable to hire more people to do the work, because they still can realize their "vision more closely" even without sufficient financial resources. Therefore, the diminished financial burden associated with the use of generative AI technologies seems to provide these indie developers with the freedom to explore and experiment with different game genres, such as:

"It is my hope that AI will bring back the golden age of gaming, where it was about fun, not profit, about creating great games. Because money will be much less of a factor to compete than before AI."

"If you have an art team or enough budget you might do better with professionals but as a solo dev imo it can definitely get you something you can use if you put in a bit of time and work with your results."

"Indy studios will use AI to make better, more fun games. And if this indeed happens, it'll be the start of a new golden era."

These posts argue that leveraging generative AI would greatly facilitate the growth of the indie community in the broader games production landscape, which may even lead to "a new golden era." For them, since using generative AI would reduce production costs and alleviate indie developers' financial pressures, solo indie game developers or small indie studios could start producing "better, more fun games" on small budgets. They might also be more encouraged and motivated to engage in more innovative and experimental endeavors in game development rather than consistently worrying about their bills.

Career Growth Risk: Generative AI may Reshape the Dynamics of Employment and Workforce in Gaming. On the flip side, incorporating generative AI in indie game development may pose career growth risks for indie developers (9.3% of posts). As highlighted in this paper, indie game developers often tend to focus on the artistic and cultural values of game development. However, using AI in their game development practices, especially for creating artistic assets for games, may harm people's job opportunities to perform such tasks, particularly when the outcomes produced by AI are deemed satisfactory. For example,

"AI art is disproportionately affecting smaller artists for sure. An artist who used to get by making commissions of people's characters for D&D portraits might find themselves losing a lot of work to basic AI tools."

"Voice actors especially get thrown under the bus and all the AI voice tech I've seen so far feels like it's being used to take away their already tiny leverage."

These developers express the concern that introducing AI-generated creative assets may take jobs away from the people currently employed in these fields. While they did not explicitly mention how generative AI may replace game programmers, a consensus seems to be that generative AI "is disproportionately affecting smaller artists" and "voice actors." These AI alternatives certainly help relieve indie game developers' financial burden by reducing development costs. Yet, they also seem to make some of the already marginalized individuals in the indie game development community, such as independent artists and voice actors, even more marginalized by posing more severe financial insecurity and unemployment upon them.

Others even add concerns about the future employability and career trajectory for everyone in the broader gaming industry, such as:

"In the future, some companies/studios won't hire concept artists anymore because they basically have AI to do that stuff for them."

"I know some many voice actors who are getting less/no work because of a lot of people using AI for their end products (who was working with indies)."

The prevailing sentiment shown in these posts is that the growing role of generative AI may not only shrink indie developers' job opportunities but also harm everyone's career trajectory in the broader gaming industry. Regardless of small indie teams, for-profit indie studios, or traditional AAA companies, *"they basically have AI to do that stuff for them."*

4.1.2 Generative AI Generates Ideas and Concepts to Jumpstart Game Design and Development but Results in Creativity Risk for Indie Game Developers. Indie developers' online discussions also highlight how generative AI can be particularly beneficial by **generating ideas and concepts to jumpstart their game design and development** (7.9% of posts). For example,

"AI saved me a ton of time on making my own concept to model from, its tutored me in better use of code and unity, and it helps me write simple scripts saving me a ton of time, it can be helpful as a starting point for narrative design and marketing assets, it can point out mistakes and recommend corrections."

"I use it to help generate NPCs and NPC dialogue. I re-write (and usually shorten) everything it gives me, but it helps me give them different personalities without having to spend excessive amounts of time thinking about it."

For these developers, using generative AI could expedite their game design and development process by offering basic game design concepts and narratives, intelligent templates, and placeholder content. In doing so, they do not need to start from scratch (e.g., *"making my own concept"*) but already have a foundation to work on and expand upon. This seems to be an especially valuable opportunity to indie developers who already have certain skills, as several posts point out,

"The AI for the normal user is a nice gadget/tool to create some nice pictures; AI used by someone with at least a little bit of artistic knowledge/skill or image editing skills can without question create professional results."

"Think of AI as a brush in your hand. It's your vision, your strokes that create the final picture."

Here, the argument is that generative AI can be used to not only jumpstart indie developers' creative practices but also amplify their artistic visions and improve the quality of their final products. The second post specifically describes generative AI as *"a brush"* in a developer's hand. While this brush is an essential tool to actualize (*paint*) the final product (*the game*), it is the individual who holds and knows how to optimize the brush (*"your strokes"*) creates the final picture. Therefore, the more skilled an indie developer is, the better the benefit from using generative AI to augment their strengths to create novel storytelling, gameplay mechanics, and visual aesthetics.

Creativity Risk: Generative AI is Unable to Maintain Consistency When Crafting the Art or Story for a Game. Conversely, others especially highlight that using generative AI in indie game development will pose significant creative risk due to its inconsistent idea generation, which can undermine the coherence and impact of a game's art and storytelling (10.1% of posts). Many posts explain,

"I can't generate solid variations that replace specifically the parts I want iterations of with the kinds of adaptations I need."

"The thing is, precision is key and I don't see AI being able to do solid iterations without it ending up as a slap comp."

"Consistency is a much stronger negative. These things won't ever be able to generate a consistent 'art style' or soundtrack without hallucinating or going off-rails."

These developers characterize the iterations produced by generative AI as *"slap comps,"* which is merely a rudimentary visualization of ideas that may not align with the desired level of detail or concreteness of an actual game as an artistic product. For the first poster, AI cannot generate *"solid*

variations" that could adapt to their game style. The second poster highlights that *"precision is key"* and suggests that AI cannot generate content that would accurately align with the developer's own visions. The third poster criticizes how generative AI is in fact unable to generate consistent variations and maintain the artistic direction of required game assets (e.g., *"art style or soundtrack"*), which is a necessity to maintain the creative flow of the game. Game artists further elaborate on this issue,

"Without artists, you'd be lacking a proper art bible. The art bible for each game clearly defines the rules for a video game's art direction, encompassing laws for lighting and color, notes about motion, and specifications for rendering materials. Without an appropriate art bible, the style of your game will be all over the place."

"Truly standout performances are unique and bring something new to the table that's not been seen before. AI functions by training itself on existing performance and data. Meaning it will likely never be able to give us those super unique performances."

For these developers, generative AI would not be able to create a proper art bible as a human artist could do, which may make the game style inconsistent and *"all over the place."* Likewise, generative AI is always trained on *"existing performance and data."* AI's inability to innovate means that the developers would not be able to create new and unique performances that adapt to the game style, which a human voice actor could easily do. Taken together, the risks seems to lie in generative AI's incapacity to comprehend how various artistic elements in a game can interconnect and lead to a coherent story in a meaningful way. This may severely impede AI's ability to maintain consistency of the developed game at the cognitive, emotional, and intellectual levels, rendering its actual benefits to the indie game development community's artistic endeavors questionable.

4.1.3 Generative AI Makes Indie Game Development More Open and Accessible to All but Causes Potential Copyright Risk. Indie game developers' online discussions further highlight that generative AI provides valuable opportunities to **make indie game development more open and accessible to all by bridging the gap between developer skills and game development requirements** (6.2% of posts). For example,

"With AI becoming ever more potent, we will see this gap closing to an extent. Its practically a very powerful force multiplier. As a first step, it will probably make every role in development more effective."

"I use Midjourney, since I'm not artistically gifted, to bring character, environmental, and layout design concepts to life."

Indeed, indie game developers often have to wear different hats in the game development process due to the solo or small-team nature of their creative practices. However, their proficiency in certain tasks, such as coding or art creation, may not be sufficient enough to create their desired products, which may discourage them from further engaging in game development. For these developers, generative AI seems to demonstrate the potential to open up the game development process even more to everyone who is interested in making indie games. As shown in these posts, developers believe that generative AI acts as *"a very powerful force multiplier"* in closing the knowledge and skill gap that prevents people from engaging in indie game development. Through these AI tools, individuals who are interested in this creative community would quickly learn all types of required skills that they might not previously have (*"make every role in development more effective"*). Using AI may also help them wear hats that they would not have been able to wear, such as creating their own game artwork despite being *"not artistically gifted."*

In particular, even if such AI tools are not used in the actual creation process, developers still believe that the existence of these AI tools alone may motivate more people to participate in driven indie game development. For example,

"I use the ai to unblock me on lots of tasks...coding to creative. It's not going to do it for you but a good chance it will give you some motivation. I think this motivates more people to do game development because you know you can use those tools if you want."

"I am a beginner in Unity and I love ChatGPT for generating quick scripts when I am not sure about syntax or how to do it in Unity. Although very often I didn't actually use them, I feel having this help makes many people like me less scared of writing our own code. Often times I do have an idea of what code to write but I don't know the Unity specifics. "

Here, the first poster felt that using AI helped them "unlock" various game development tasks by offering a sense of assurance and relief ("you know you can use those tools if you want"). The second poster even highlighted that although they did not use any AI-generated scripts in their game, the existence of the AI itself encouraged many indie developers to program their own game ("less scared of writing our own code"). In this sense, by bridging the gap between developer skills and game development requirements, generative AI seems to potentially contribute to a more inclusive and collaborative environment where everyone interested in engaging in indie game development is welcome to realize their creative visions with greater ease.

Intellectual Ownership Risk: The Absence of Copyright Protection of AI-Generated Content Leads to Misuse and Further Vulnerability. One major pitfall of using generative AI to make indie game development more open and accessible to all is that AI-generated content cannot be copyrighted, at least according to the stance of the United States Government [1]. This limitation stems from the requirement for a human author to register a copyright, leaving content produced by AI models devoid of legal protection. Even when substantial alterations are made to AI-generated content, potential copyright infringement issues can still arise if the material is based on copyrighted sources. Therefore, developers consider the potential copyright concerns as a major risk in leveraging generative AI to further open up indie game development (12.5% of posts), such as:

"Even if both you and the AI are massaging these images into some final form, they're still derivative of protected IP. It won't pass the fair use 'sniff test' of being able to stand on its own without the sourced material propping it up or being exempt due to typical fair use provisions."

"If the AI uses the voice of someone that has not given permission and your game is going to generate a revenue you will most likely get a lawsuit headed your way."

These posts make it clear that AI-generated content that uses copyrighted materials, or materials from other human creators without their consent, will lead to legal troubles for indie game developers. In particular, these developers are concerned that although it is possible for them to refine or modify the AI-generated content to avoid potential copyright infringement (e.g., "massaging these images into some final form"), it is challenging to sufficiently validate their originality and legal rights to re-use these materials ("pass the fair use 'sniff test").

Additionally, the current absence of copyright protection for AI-generated content may lead to misuse and exploitation, for example:

"If you have an AI-generated banner/cover/main character art, for example, you may not be able to stop someone from copying it and using it for themselves."

"The argument is not about AI aiding processes, it's about AI that takes pre-existing content and generating a collage of other peoples work that people try to pass as their own."

According to these posts, if generative AI is involved in indie developers' creative practices in any way, their work might be copied and used in others' products without crediting their contributions. Even worse, people can take their work and claim it "as their own." As indie game developers are already facing several challenges regarding labor, capital, and production in their creative practices [13, 17, 31, 42, 57, 60], these new risks paint a worrisome image where these developers may become even more vulnerable in the emerging age of generative AI.

Considering this potential risk, many developers thus express strong reservations against widely using generative AI in indie game development:

"AI smells. It is quite easy to understand it is done by a computer, and people immediately devalue anything using AI as cheap and low quality."

"As far as the community is concerned, the use of AI-generated images in a video game can potentially result in a review bombing, as there is a lot of hostility towards the use of AI image generation due to potential ethical concerns."

"A lot of artists out right refuse to work on a game with AI art is used anywhere in it. Morally, they don't like that you've replaced an artist's job with a computer. "

These developers' reluctance to use generative AI is not solely due to aesthetic considerations but also based on solid ethical concerns. First, there seems to be a growing tendency to associate AI-generated content in games with being *"cheap and low quality."* This motivates many indie developers to strongly oppose the idea of using generative AI in game development and further de-associate themselves and their work from generative AI. Second, there also seems to be a hostile perception of AI-generated content as ethically problematic due to the assumption that *"you've replaced an artist's job with a computer."* As such, how generative AI can be used in an ethical and fair way to further support, rather than suppress, indie game developer's creative and artistic endeavors would require more future work and careful considerations.

4.1.4 Generative AI Serves as a Supportive Co-Worker for Solo Developers but Requires Significant Personal Investment. Lastly, a common concern in the indie game development sphere is that since many developers work alone or in very small teams, they may lack necessary methods and opportunities for exchanging ideas and feedback with potential teammates. Indeed, unlike larger studios, indie developers often face the challenge of missing out on the daily discussions and collaborative sessions that often fuel innovation. Interestingly, generative AI seems to offer another alternative practical solution in this solitary setting by **servicing as a supportive co-worker who can offer immediate insights, feedback, and suggestions** (8.4% of posts). Some developers thus call generative AI a *"rubber duck"*:

"It also helps with certain troubleshooting areas of code in case I need a pair of eyes. Think of it like a rubber duck, but the rubber duck talks back."

"ChatGPT is really good with finding edge cases and explaining code in written form, which is good if you are familiar with Rubber Duck mechanism, even if chatGPT does not find any issue, just reading the explanation of code gives cues for any edge case."

"Rubber duck debugging" is the idea that a rubber duck can help developers debug a program by serving as an embodied listener when a person explains the code aloud step-by-step [68]. For these developers, generative AI plays an important role as a co-worker in two ways. First, it is a "rubber duck" that is always present and available when they need it, which can provide another *"pair of eyes"* as a co-worker who would help them solve coding problems. Second, in contrast to an actual rubber duck, generative AI is interactive and responsive because it *"talks back."* In this sense, it goes beyond a passive listener and becomes an active actor in these developers' creative process, providing a social entity for them to converse with and bounce ideas off.

Other posts further elaborate how they see generative AI as an experienced yet *"ill-informed"* co-worker that they could turn to for support, feedback, and suggestions at any moment:

"I'm a solo developer and chatgpt is a godsend. I'm not a coder. I'm pretty good at reading/modifying existing code but suck at writing my own. Prompting chatgpt will give me enough info to get something started. It's not a replacement for a coder for me, but a somewhat ill-informed coworker to bounce-off."

"I basically use ChatGpt as a form of tutor to help me understand concepts that don't require me googling it and then having to scroll through snippity responses to get the answer that ChatGpt can give me within a few seconds flat."

As shown in these posts, not every indie game developer has all the required skills to make their game, which means that they usually have to learn new skills and knowledge. In larger studios, these learning processes would be performed by a senior mentor or a more experienced co-worker. Yet, many indie developers do not have the same access to these resources due to the solo or small scale nature of their creative practices (e.g., *"I'm a solo developer"* but *"I'm not a coder"*). As a result, generative AI models such as ChatGPT can act as teachers or tutors who are always accessible to help these developers learn new concepts, skills, and necessary knowledge for game development. Although these AI tools are still *"somewhat ill-informed"* and cannot replace a human co-worker (e.g., *"It's not a replacement for a coder for me"*), compared to just searching such information online, working with generative AI is not only easier (*"don't require me googling it and then having to scroll"*) and faster (*"within a few seconds"*) but also more iterative. As the second post highlights, this is especially valuable for indie game developer who works alone, as they can treat AI as *"a second game designer"* whom they can work together to refine their game through conversations.

Some developers even describe generative AI as a co-worker who provides **emotional support**. As indie game developers often work solo or with a small team, they might experience feelings of loneliness due to the absence of peer interaction typical in a workplace. This loneliness, coupled with continuous financial pressure, turns indie game development mentally and emotionally challenging [13]. In such cases, developers seek to use generative AI to express frustrations and emotional burdens without the discomfort of bothering others:

"Well, sometimes I say some things off my chest to ChatGPT that I feel would make my friends uncomfortable, which helps a little with stress. Definitely helps me process stressful events a bit better!"

"I've always found it interesting how little friends/family try to empathize with programming problems. I'll sit there and listen to someone complaining about their client xyz, offer sympathy for work problems, etc. But the moment you start about something code-related, even if you simplify to spare them the details, people just switch off. So I have tried to just talk about these with AI."

These posts reveal a perspective on AI that mirrors the concept of using a rubber duck for debugging. However, here AI is seen as an emotional support rubber duck, which acts as a co-worker who helps with indie developers' emotional struggles rather than technical challenges in their creative practices. These emotional struggles are also compounded by the lack of understanding or social support for these developers and their issues. As these posts show, there is a stark contrast in the level of empathy received for indie game developers' challenges compared to other work-related grievances. This further underscores how indie developers who work solo or in small teams can feel isolated during their creative practices, which motivates them to turn to generative AI as their "emotional crutch" in navigating the challenges of creative solitude.

Personal Investment Risk: Training Generative AI to be a Co-Worker Leads to Extra Workload and Distractions. While indie game developers are enticed by the promise of generative AI to alleviate their intellectual, mental, and emotional burdens, training AI to be a supportive co-worker would require a substantial personal investment, leading to an additional workload that distracts from their core focus: game development (8.8% of posts). The following posts show,

"Emotional tone, breathing & non-verbals, word-part emphasis, pacing, cultural-specific inflection, pronunciation, etc... These pretty much all need reviewing & tweaking with an AI to sound truly natural & fit the context. All of which a good voice actor will either do naturally or ask for direction on."

"I've yet to see one piece of AI code that can actually be integrated into a game project without a programmer doing the integration and hooking it up to other systems, fixing issues and bugs, rewriting pieces for better optimization etc."

For these developers, instead of having actual human co-workers to complete these tasks, the process of training generative AI models as a co-worker who can meet their specific needs is time-consuming. Compared to working with a voice actor who "will either do naturally or ask for direction" or a human programmer who can "fix issues and bugs, rewrite pieces for better optimization," they must invest significant effort in fine-tuning the AI algorithms, adjusting parameters, and providing feedback to ensure that the generated outputs align with their creative vision and technical requirements. This iterative process demands a considerable amount of trial and error, which distracts them from focusing on making the actual game.

As such, attempts to utilize generative AI as a co-worker to develop games may sometimes result in unnecessarily longer development cycles and additional workload. For example,

"As someone who tried to use AI to make me code faster, frankly, it took longer for me. I had to debug and ended up rewriting a good portion of the code."

In summary, some developers have begun to question the value and contributions of using generative AI to support indie game development as their co-worker. For them, while these generative AI tools can provide immediate insights, feedback, and suggestions, they may produce flawed or incomplete outputs, which would still require significant human intervention for quality assurance. This extra process to add generative AI as a co-worker in fact slows down rather than facilitates their development progress.

4.2 Indie Game Developers' Envisionings of Future Generative AI for Their Efforts

Thus far, our findings have identified the novel opportunities for leveraging various generative AI technologies to facilitate indie game developers' creative practices while also acknowledging and outlining generative AI's **Career Growth Risk**, **Creativity Risk**, **Intellectual Ownership Risk**, and **Personal Investment Risk** for these developers. Indeed, indie game developers have also discussed and envisioned several essential recommendations for designing and appropriately using future generative AI systems to mitigate these risks while maximizing the identified promising opportunities for their use.

4.2.1 Establishing Developer-Artist-AI Collaboration to Address Career Growth Risk and Creativity Risk. To address generative AI's *Career Growth Risk* and *Creativity Risk* for indie game development, indie game developers' online discussions have pointed out a promising middle ground where developers, artists, and generative AI can collaborate together to improve the consistency of their games without displacing human creativity. For them, establishing such a **Developer-Artist-AI Collaboration** mechanism is the key to both leverage generative AI for fast, cost-effective, and coherent game creation and ensure the career growth of indie developers with various skills (9.2% of posts). Several posts explain this envisioned mechanism,

"Stable diffusion to run over initial drafts of our artists, then the artist use that as a base to do the real magic. The pipeline was hugely accelerated. I think in this case works because the original style of the artist was appropriate to experiment with that workflow and the theme of our game can leverage the 'surreal' and abstract feel you often get."

"One scenario I see is a graphics designer creating a design vision of a game, feeding the AI, and then let the AI create most of the content based on the combination of its learned, generalized data and the consume data the designer fed it. The designer would then guide it to create the content needed, vastly reducing the time to create new assets. The same will no doubt also come to the 3d world."

"I've used Dall-E to generate headshots for characters that I gave to a concept artist as sort of a jumping off point for what I was going for."

All three posts thus envision that establishing this *Developer-Artist-AI Collaboration* mechanism would help indie game developers achieve their artistic pursuit rather than eroding their career in two ways. First, generative AI offers a valuable tool to produce initial artwork. This approach simplifies communication between developers and artists, as providing initial drawings often proves more effective than conveying ideas solely through textual descriptions. Second, the AI-generated initial artwork will then serve as a starting point for an interactive and iterative collaborative process through which developers, artists, and AI continue to refine the artwork into final assets. As these posts show, *Developer-Artist-AI Collaboration* is not an one-time endeavor but a "pipeline" and a "base" for developers and artists to work together to "do the real magic." In this sense, generative AI does not replace human developers and artists in the game development process but streamlines how they can work with each other, which will also lead to more consistent game art and story. One post summarizes,

"I will still need to pay a concept artist to make it, but I can now send the concept artist my AI art to use as references, for moodboards, concept descriptions, etc., which should mean a lot less time spent by this person, which ideally translates to them being able to offer me a cheaper price because they can do more projects with their time."

According to this developer, generative AI technologies can bridge gaps in some indie developers' artistic skills and facilitate smoother collaboration between developers and artists. For example, developers may save their time, effort, and financial resources when they need artwork for their games (e.g., "offer me a cheaper price") whereas artists can grow to be more creative and productive because they do not have to start from scratch ("a lot less time spent by this person" and "do more projects with their time") and have better control over the consistency of their final products. As a result, this collaboration may ultimately enhance the overall quality and efficiency of their creative practices.

4.2.2 Building AI Models that Reflect Unique Personalized Artistic Styles to Address Intellectual Ownership Risk and Creativity Risk. To address generative AI's *Intellectual Ownership Risk* and *Creativity Risk* for indie game development, indie developers envision training AI models to reflect unique personalized artistic styles as a promising approach (6.9% of posts), such as:

"I'm making games based on the art of my kid, who is on the autism spectrum. As he's getting older, his art style, as well as his choices in mediums has changed. So I trained a model for A1111 on his older style and can use that to generate things that either he's not inclined to draw, or doesn't know what they look like."

"But cases like yours, where a developer trains AI on their own work in order to aid the production of truly original art? That's the main reason I love and don't fear the AI revolution for game developers."

These posters tend to acknowledge that content generated by an AI model trained on large scale, heterogeneous data may not be copyrighted due to the difficulty to tease out and credit specific individuals' contributions. Yet, they point out that a generative AI model can also be trained exclusively based on a particular aesthetic that only belongs to a unique individual. For example, the first post mentions training an AI model specifically based on their children's creative products to reflect their children's unique art style ("*the art of my kid, who is on the autism spectrum*"); and the second post highlights the possibility of training an AI model based on developers' own code ("*a developer trains AI on their own work*"). In this sense, content generated by such an AI model can be copyrighted because it is directly built upon and reflects a particular individual's intellectual property rights. Therefore, this approach can minimize the risk of intellectual property violations because these developers could "trademark" the generative AI model and its output, addressing

generative AI's *Intellectual Ownership Risk*. It can also help indie developers create original content that is consistent with their own personal styles, which addresses generative AI's *Creativity Risk*.

Others further add an alternative method to only rely on generative AI models that are trained in an ethical and legal way:

"So I guess legally it's alright to do if the service you're using is reputable and said company has the rights to all the raw voice files that the AI uses."

"My rule for anything AI is being able to show the tech was only trained on licensed data."

For these developers, even if they do not have the necessary resources to train and "trademark" an AI model based on their own work, the least they could do is to only use AI models trained on data that has been properly licensed. For them, this would be a practical strategy to both protect them from copyright infringements and demonstrate their commitment to upholding intellectual property rights in the indie game development community. This envision thus reflects how indie developers can leverage AI's capabilities to facilitate the creation of original artwork while still sidestepping potential copyright concerns.

4.2.3 Adjusting the Focus of Generative AI to Various Skill and Experience Levels to Address Personal Investment Risk. Finally, to address generative AI's *Personal Investment Risk*, these developers collectively envision adjusting the focus of generative AI to cater to different skill and experience levels as a potential approach (7.9% of posts). For example,

"AI tools can help experienced artists, programmers, musicians, designers, to produce things they already can produce by circumventing some resources or time sinks."

"I would usually ask Bing AI on how to implement specific patterns and which pattern might be the best for x situation, it helps me learn much better and grasp my head around most concepts too."

As these posts show, for more experienced indie game developers who already possess a deep understanding of game development, generative AI may be best used for streamlining workflows (e.g., "circumventing some resources") and simplifying complex tasks while providing targeted assistance where needed. Conversely, novice developers may require more detailed and hand-holding type guidance and support from AI models to navigate the intricacies of indie game development ("how to implement specific patterns"). In this sense, tailoring generative AI to specifically focus on different tasks based on developers' skill levels may be able to provide them with more meaningful and targeted assistance and support rather than adding unnecessary complexity or distractions.

Others also add that generative AI should be designed to support both micro-level and macro-level aspects of game development based on individual indie game developers' own choices, such as:

"I think it's best used in any case where the sheer volume of art required is intractable under normal circumstances."

"I'm waiting for the ability to have it ingest the entire UE source code and annotate / add it's own documentation or just make it queryable. I've done it with chunks of code pasted into the window for now."

"There will be a service where you can put in a vague description of a game... and it will produce the .exe file for you, including whole 3D worlds, characters, plot, everything."

Here, the first post focuses on using generative AI to support higher-level creative tasks such as generating large amount of required artwork in a short time frame. In contrast, the second post expresses the envision for generative AI to provide detailed teaching and guidance resources at the micro-level for less experienced developers to learn game programming ("ingest the entire UE source code and annotate / add it's own documentation"). And the third post even envisions that future generative AI should provide personalized recommendations for novice indie developers to automate the entire game development process ("put in a vague description of a game... and it will

produce the .exe file for you"). Certainly, building a universal AI model to meet all these needs would require tremendous personal investment. In fact, different developers may just need different AI functions, rather than all these functions simultaneously. As this post suggests,

"It basically helps lower experienced/skilled workers catch up. If you are already working fairly optimally then it doesn't help you, but if you are doing something totally new to you, then it can help speed you up."

Therefore, a better way to leverage generative AI to support indie game developers seems to focus the AI's key tasks to specific areas at various stages of their careers. This would also reduce the amount of *Personal Risk* from these developers to make the AI align with their actual needs. For example, for newcomers and less experienced indie developers, using generative AI should focus on helping them *"catch up."* In contrast, for more experienced indie developers, using generative AI should focus on helping them *"learning something totally new"* more efficiently because they are already familiar with all basic knowledge and skills involved in game development.

5 DISCUSSION

In addressing our two research questions, Table 1 summarizes our key findings. In this section, we first discuss how our findings offer new insights on emerging opportunities and risks of generative AI that indie game developers face in their efforts to innovate game development, thus contributing to better understanding how generative AI is actively shaping the nature and workflow of creativity in game development nowadays. Based on these, we then identify potential future directions for designing generative AI in ways that empower rather than deprive indie game developers of creativity control, autonomy, and agency in their game development processes.

5.1 New Insights on Generative AI's Emerging Complex Roles in the Context of Indie Game Development

While there has been substantial discourse surrounding the utilization of generative AI in various creative fields [8, 18, 20, 24, 27, 32, 36, 39, 63, 67, 74], research specifically focusing on its application within the game development domain has been notably scarce. In particular, although current research has explored the use of generative AI for coding and programming tasks [30, 64, 66], the unique demands of indie game development, which endeavor to innovate the traditional game production model by focusing instead on the creative, cultural and artistic values of games [11–13, 17, 21, 22, 51, 57], have largely remained unaddressed. Our study thus sheds light on this gap and highlights the pressing need to further explicate the new and complex roles of generative AI play in indie game development, which are both promising and damaging: (1) *generative AI as potential empowerment* to further democratize game development; (2) *generative AI as an emotional companion* to make indie game development less lonely and emotionally draining; and (3) *generative AI as a possible threat* to make indie game developers' efforts less sustainable.

(1) Generative AI as Potential Empowerment to Further Democratize Game Development. Above all, our findings highlights generative AI as an emerging opportunity to empower solo indie developers and small indie teams by helping them overcome barriers to entry, streamline production workflows, and unleash their creative potential with low cost. This new opportunity especially highlights how generative AI can potentially further *democratize* the game development process, which is traditionally seen as highly technical, expensive, and expert-focused.

Indeed, in our study, indie game developers acknowledge that regardless of their prior skills and experiences in game development, generative AI can equip them with the necessary tools to navigate the complexities of game creation effectively and with less financial burden, ranging from coding support to generating artwork, character design, narrative writing, and musical composition. These findings thus underscore the transformative potential of generative AI in bridging skill gaps

and enabling indie developers of varying experience levels to produce creative content despite with little financial support. In this sense, leveraging these AI tools seem to have the potential to significantly facilitate indie developers' agenda on pursuing a more participatory and democratic form of game development [11–13, 51] by making the game development process more accessible and inclusive, particularly for those lacking extensive expertise and financial resources. By relieving these developers from certain technical, creative, and financial hurdles through AI tools, they can jumpstart their game creation with confidence and efficiency. This thus means they could focus more on creating games that reflect their values and artistic visions rather than being too distracted from tedious tasks and financial concerns in game development, which significantly contributes to their aspiration of being a new counter-culture compared to the mainstream gaming industry [11, 25, 62].

(2) Generative AI as an Emotional Companion to Make Indie Game Development Less Lonely and Emotionally Draining. As indie game developers are not employed by or affiliated with a specific studio or company, they may not be co-located with other indie developers and often have to rely on various online platforms (e.g., social media, online forums, and live streaming) to find collaborators, stay in touch with one another, and maintain a sense of community [11–14, 17, 21, 22, 35, 51, 57]. However, this lack of frequent face-to-face interaction with their peers may also make their game development process a solitary and emotionally draining journey [13, 47]. Therefore, unlike traditional views that position AI primarily as an instrumental entity for tasks [8, 18, 20, 24, 27, 32, 36, 39, 63, 67, 74], another unique insight from our data is the emerging trend to utilize generative AI for *emotional support* as a personal companion. For example, in our study, indie game developers view generative AI as a "rubber ducky" that they can always chat with to ask questions and relieve all kinds of pressure. They also consider generative AI as an ally similar to a mentor or senior colleague from whom they could seek guidance, encouragement, and emotional support.

In addition, while some prior work has mentioned that generative AI may be seen as a tool or a co-performer/co-participant in creative practices (e.g., design or programming) [23, 30, 66], our research delineates an even more distinct parallel between generative AI and similar human co-workers within the workplace. Our data shows that indie game developers frequently compare their interactions with generative AI to those they would have with a human co-worker in the game development process. They especially highlight generative AI's role in facilitating brainstorming sessions, overcoming challenges, and engaging in social and informal conversations. This constant comparison between generative AI and human co-worker seems to elucidate the multifaceted nature of generative AI's role in these developers' creative practices, which extends beyond its technical capabilities to encompass social and collaborative dimensions akin to human-human interactions. This insight thus foregrounds the evolving social aspect of generative AI in indie game developers' creative endeavors. Therefore, how to better leverage the potential of generative AI to mitigate feelings of isolation and draining and foster a sense of emotional support within the indie game development community becomes an important new question, which is critical for this unique community's overall well-being and productivity in the future.

(3) Generative AI as a Possible Threat to Make Indie Game Developers' Efforts Unsustainable. Despite the above-mentioned positive perceptions, it is critical to highlight that indie game developers' online discussions demonstrate a clear and evident concern regarding the use of generative AI in indie game development. Many developers view generative AI as a double-edged sword, which introduces not only promising opportunities but also possible and imminent threats to make their efforts less sustainable. Indeed, we have seen that although AI-generated content offers faster and cost-effective outputs, this approach may hamper these developers' employment

opportunities and may even change the future workforce structure in the gaming industry. Likewise, while generative AI may offer efficiencies in content and idea generation, developers often encounter issues with the consistent quality and compatibility of AI-generated assets, which may in fact slow down rather than facilitate their game development processes. New copyright controversies surrounding AI-generated content and the additional workload to train AI to become a supportive and valuable "co-worker" further introduce new layers of complexity to approach the use of generative AI in indie game development.

Therefore, there seems to be a sense of fear and hesitancy towards generative AI among some indie developers. For them, it is still unclear whether the opportunities offered by generative AI can overcome the risks that come with it. As reflected in some posts, generative AI has the potential to *damage* these developers' creative efforts and may even harm the definition of "creativity" in game development due to the current absence of necessary regulations and quality control for AI-generated content. This thus leads to many unanswered questions: What if the AI-generated content does not align with, or even destroys, an indie game's intended artistic and cultural goals? Or, what if an artist or a developer was hired and expected to deliver quality work for an indie game but instead used AI to generate low-quality assets that do not fit the artistic style or theme of the game? Regardless, involving generative AI in indie game development may lead to significant time delays (e.g., humans need to redo the work to replace all AI-generated assets), which for indie developers with tight timelines and limited funding can mean the loss of their entire project [13, 17, 31, 42, 47, 57, 60]. In this sense, generative AI, if not constructed ethically and carefully, will likely make indie game developers' efforts unsustainable. Ultimately, indie game developers must carefully weigh the benefits and risks of generative AI and develop strategies to mitigate its potential risks to avoid jeopardizing the creativity and innovation that defines their community.

5.2 Future Directions for Designing Generative AI to Support Indie Game Development

Based on indie game developers' own recommendations for addressing generative AI's risks for their creative practices, in this section, we propose three high-level principles aimed at facilitating the design and development of future generative AI technologies to strengthen the identified opportunities while mitigating potential risks and harm.

Principle 1: Designing Customized AI Models for Supporting Varied Skills and Reflecting Personalized Artistic Styles Than a Universal One-fits-all Tool. First, an important principle for designing future generative AI technologies is to acknowledge indie game developers' skill disparities and personalized artistic styles and address them through a more nuanced approach, as the current landscape of generative AI models often falls short of catering to this diversity.

In doing so, it is crucial to allow indie game developers to customize AI outputs according to their proficiency levels and artistic preferences. For instance, for coding assistance, indie developers could indicate their experience level, allowing the AI to adjust the complexity of explanations and solutions accordingly. More specifically, novice developers may choose the setting of detailed, step-by-step guidance to learn game development fundamentals and enhance their skills with AI assistance, whereas seasoned experts might choose the setting of high-level suggestions to expedite their workflow. In addition, when it comes to the artistic aspect of game development such as artwork generation and voiceover production, future generative AI technologies should better reflect developers' distinct aesthetic preferences that shape the overall style and tone of their games. In doing so, such technologies should provide developers with additional tools to articulate these personalized preferences and tailor AI-generated content to match their unique visions, which would help distinguish or "trademark" their products (i.e., games) from others and thus mitigate potential copyright issues. One possible way to help achieve this goal would be encouraging and educating indie game developers to master the art of prompt engineering [55], such as providing

tutorial and training modules to enhance their ability to communicate effectively with generative AI systems. This may help them better articulate their artistic visions with greater precision and clarity to better direct AI to generate customized content that directly reflects their own styles.

Principle 2: Designing Generative AI to Support Both Human-AI Collaboration and Human-Human Collaboration in Indie Game Development. Rather than viewing generative AI as a replacement of human employment in indie game development and in the broader gaming industry, we propose an essential principle that emphasizes collaboration between humans and AI as well as fosters collaboration among humans themselves through generative AI to mitigate these concerns. While some prior works have mentioned promoting human-AI collaboration or developing more participatory generative AI as potential directions to mitigate generative AI's challenges for creative work [7, 15, 18–20, 27, 74], indie game developers have more nuanced needs for creative support through generative AI. In this context, generative AI is not only expected to collaborate with developers with distinct backgrounds, skillsets, and creative needs such as programmers, artists, or designers (**human-AI collaboration**) but also facilitate coordination and communication among them (**human-human collaboration through AI**).

To support *human-AI collaboration* rather than solely replacing human labor in indie game development, one approach is to design future generative AI tools to focus on suggesting visual elements or themes based on input from game artists, thereby sparking inspiration and facilitating brainstorming sessions. These human artists can then refine and customize AI-generated initial suggestions to align with their own unique artistic vision, leveraging generative AI as a creative assistant rather than a replacement. Similarly, future generative AI tools can be designed to support the voiceover production process in game development by incorporating two specific steps. First, AI will generate voices as placeholders or supplements for indie game developers to quickly prototype dialogue or narration within their game. Next, human voice actors will then add their unique expressions, emotions, and nuances to the prototype and then finalize the character voices or narration.

To support *human-human collaboration* in indie game development, on the one hand, future generative AI can be incorporated in other tools and platforms for these developers to network and showcase their creativity. For example, on online marketplaces or collaboration hubs where independent artists, voice actors, and story writers can connect with each other and seek collaborators, generative AI can be used to help curate and match talent based on artist styles and game development requirements, which may help indie game developers discover new collaborators and build diverse and dynamic teams for their projects. On the other hand, future generative AI can also be used to facilitate human-human collaboration on specific game development tasks. For instance, generative AI can be incorporated in the chat feature within collaborative tools and applications that these developers often use (e.g., Zoom, Discord, Slack) to communicate with their team. In doing so, when artists, designers, and programmers are brainstorming and iterating over ideas in the game development process, AI can be used to create images based on their discussion to quickly visualize their ideas.

Principle 3: Designing Generative AI as Both an Instrumental Entity and a Social Entity to Support Indie Game Developers. Lastly, we highlight the importance of designing future generative AI as both an instrumental entity and a social entity. This constitutes a comprehensive approach to better support and sustain the indie game development community's efforts to innovate game development. This principle essentially acknowledges generative AI's dual role: as an instrumental entity facilitating pursuing artistic and cultural values in game creation and as a social entity relieving emotional and mental burden involved in indie game development.

While the first two principles have focused on how generative AI can be designed as an *instrumental entity*, generative AI as a *social entity* should play a pivotal role in providing indie

game developers, especially those who work alone, with necessary emotional support qualities to mitigate the feeling of loneliness and mental burden in the development process. In this sense, if designed appropriately and ethically, future generative AI can go beyond just a technical tool for content creation but become a supportive companion for these developers, because not everyone in this community would have access to these much needed social support from other humans. For example, if a developer expresses frustration over a task, the AI companion could provide encouragement, suggest alternative approaches, or if necessary provide external sources to tackle the problem. Developers may also be able to tailor what type of emotional support they want to receive from AI (e.g., emotional support for boosting self-esteem or combating loneliness or depression) and how they want to receive such support (e.g., as text chat, voice, or emoji) based on their personal emotional needs. Certainly, the goal of designing generative AI as companions is not to replace social support that indie game developers would receive from other humans and the community. Instead, this approach aims to leverage generative AI as an ally who can offer supplementary emotional support and companionship, especially when such support from other humans or the community is not immediately available in the moment. In this sense, future generative AI may be able to contribute to fostering a positive atmosphere within the indie game development community, where developers constantly feel valued and supported in their creative endeavors.

5.3 Limitations and Future Work

This study has several limitations. First, we only used data from subreddits and Facebook groups that are popular among indie game developers, where the users demographics can be skewed. For example, most Reddit users are located in the United States (42.95% global traffic), United Kingdom (5.46% global traffic), and India (5.18% global traffic) [2]. Additionally, Reddit and Facebook are mostly English-based platforms, further restricting our findings to an English-speaking sample. As indie game development has become a global movement, our findings may not reflect how indie developers across different regions and cultures perceive the role of generative AI in their creative practices. Second, our findings are also limited to the scope of the collected textual data itself and our search queries. For example, the collected 3,091 posts and comments may lack the richness of context and the generalizability to explain all possible perceptions of using generative AI in indie game development. While we included a variety of search queries to collect data, the list of keywords we used may not be exhaustive and still may not include all related online discussions. Therefore, our future research will focus on further verifying and deepening the findings from this study by using different data sources and data types, such as conducting in-depth interviews, large-scale surveys with indie game developers across various regions and cultures, and analyzing this larger data with more automated methods like topic modeling. Additionally, as generative AI has been used across various creative sectors, it would be valuable to investigate how our findings regarding AI's opportunities and risks for indie game development are similar to or differ from those the mainstream gaming industry (i.e., AAA studios and developers) and even other creative industries related to game development (e.g., music production) are also facing. Such research would not only further unpack the unique challenges indie game developers may face in the era of AI but also help situate AI's complexity in the broader context of entertainment computing and creativity.

6 CONCLUSIONS

The rapid proliferation of generative AI applications has permeated the realm of indie game development, a unique community characterized by solo or small teams of developers driven more by artistic and cultural expression. In this paper, our investigation has shed light on the

multifaceted impact of generative AI in this community, revealing its capacity to facilitate focused and cost-effective game creation, expedite content and idea generation in the development process, promote inclusivity and accessibility within the field, and provide valuable social support to solo developers when needed. However, alongside these opportunities, generative AI also presents a range of risks and potential harm for these game developers, including: limitations on career advancement, constraints on creative expression, exposure to copyright infringement risks, and the inherent time and effort required to navigate the complexities of training AI as a supportive co-worker. In response to these findings, we propose three design principles aimed at harnessing future generative AI to enhance indie game developers' creative endeavors while mitigating potential harm. We hope that these insights can pave the way for further exploration of generative AI's complex roles in indie game development and the broader creative landscape, which may help design and develop future generative AI technologies to foster and sustain more democratic and inclusive practices in game development rather than replacing human creators.

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