Calling for Play-oriented Research on Blockchain Games: An Overview Study

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Calling for Play-oriented Research on Blockchain Video Games: An Overview Study

Play-oriented Blockchain Video Games

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Blockchain video games, specifically video games using blockchain technology, are a trending topic in the media, technology community and business world. While blockchain video games are expected to transform the industry, little is known about how they are played and the players accordingly. The paper presents a 3-stage literature overview study on blockchain video games combining methods of topic modelling, bibliometric analysis, and narrative literature review. In a systematic approach, 1883 articles are screened. Language models are built on 1246 papers, and 70 articles directly related to blockchain video games have been analysed. The results indicate that most recent studies focus on blockchain technology and its financial characteristics instead of players. Hence, more play-oriented blockchain video game research is needed. Future studies may focus on different types of blockchain video games, game design and playability, players' experiences, and critical reviews.

CCS CONCEPTS

• Applied Computing • Operations research • Consumer products

• Human-centered computing • Interaction design

Additional Keywords and Phrases: blockchain video games, blockchain, video games, topic modelling, bibliometric analysis, play-oriented research

1 INTRODUCTION

Blockchain video games (also usually referred to as “blockchain games,” “blockchain digital games”, or "cryptogames" by practitioners) combine blockchain technology with video games [1, 2]. Due to blockchain technology's novelty and complexity as a kind of decentralised ledger technology, blockchain video games are expected to disrupt the industry. The blockchain market's previous success reinforces this belief. For instance, CryptoKitties[1] is widely recognised. Over 25 million dollars have been exchanged in this game since 2017. While the general blockchain industry declined by 2020, blockchain video games grew 46-fold and represented 52% of blockchain network usage [3, 4]. Blockchain video games are still considered to drive blockchain development and provide additional value to players, developers, and designers. However, blockchain video games are criticised for their poor game design by practitioners [2, 5]. For example, F1 Delta Time, one of the first blockchain video games, ended after three years with no players around. After the game was terminated, its digital assets became worthless [6]. Decentraland[2] and The Sandbox[3], despite $1 billion valuations, report less

1 https://www.cryptokitties.co

2 https://decentraland.org

3 https://www.sandbox.game/en/

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than 1,000 daily active users [7, 8]. Current blockchain video games are usually not made by game companies nor run in a typical **game** business mode [9]. The direct playing experience of blockchain video games seems to be overlooked.

Therefore, we propose that **play-oriented** research on blockchain video games may be the required update. As defined in this paper, play-oriented blockchain video game research sees blockchain video games as games rather than purely technical products of blockchain technology or tools for finance. Play-oriented blockchain video game research aims to examine how blockchain video games are designed and played [10] and to contextualise existing game studies and game research results in the context of blockchain video games.

This paper systematically investigates the existing blockchain video games research environment in order to validate our proposed play-oriented research approach on blockchain video games. The following questions are addressed in this paper:

Q1: Are there well-defined research directions in blockchain video games? If so, what are they?

Q2: What are the future agendas for blockchain video game play-oriented research?

To emphasise, this paper aims to provide an overview of current **research** on blockchain video games. Without a doubt, specific blockchain technology and architectures are crucial parts of blockchain video games. A detailed investigation of blockchain technology in games would require a study of its own and thus is out of scope for this study. This overview could, however, serve as a stepping stone for future investigations of technologies used in blockchain video games.

This paper has following sections to answer the questions: Section 2 describes the background of blockchain video games research. Section 3 is the over-arching design of this overview. The overview has three stages, which are reported in sections 4, 5 and 6. Section 7 provides the discussion of the results and Section 8 is the conclusion.

2 BACKGROUND

There exists some pioneering research on blockchain video games and can be generally put into two categories. One is to consider blockchain video games as a whole and discuss at an industry level. For example, Guidi et al. [11] acknowledged the impact blockchain games can have on a metaverse (i.e., "a video game or a digital life simulation where people can interact with other users using a character, or avatar, which represents themselves") and bring social impact. Mataruna-dos-Santos et al. [12] locates the role of cryptocurrencies (realized through blockchain) in games and esports, facilitating the so-called "ludic economy." One concern of research in this category is that it tends to mix related yet different concepts such as "blockchain games," "metaverse," or "cryptocurrency. [13]" There is a lack of solid definitions and details.

The other category, which is more related to play-oriented blockchain video games, digs down the design of and users' interactions with blockchain video games. Min et al. [2] described an architecture for blockchain games and did a survey on 23 representative blockchain video games. These representative games are categorised based on the affordances of blockchain technology in the game with some data showing the activity of players. Scholten et al. [14] in 2019 also surveyed some blockchain games and, specifically, mentioned generally the gameplay of these games. Nevertheless, the settings of each gameplay and game design are not investigated in a detailed way in these studies. An interesting literature review by Denden et al. [15] found game elements (e.g., points, badges and leaderboards) used in blockchain, which may inspire the designers of blockchain games. However, their focus was on the gamification of blockchain systems rather than on blockchain video games as video games.

To our knowledge, it seems current academic research lacks updated information about playing-related critiques on blockchain video games, whether in the form of reviews, empirical studies or theoretical studies. These game-play issues are actually essential for the long-term success of blockchain video games, given the importance of sustainable players' activity in a game (for example, as seen in the context of geolocation augmented reality mobile games [16]). Therefore, a systematic and comprehensive overview of play-oriented blockchain video games is essential.

3 DESIGN OF THE OVERVIEW

This overview study presents a three-stage consecutive investigation to answer the research questions. Since the study uses objective records, such as published papers and online archives, a structured literature review was chosen. Review planning, review conduct, and review reporting are performed sequentially in each stage under the guidelines proposed in [17].

First, a topic modelling on **all** the full text of papers collected as broadly as possible is conducted. This stage aims to have a preliminary, yet comprehensive, grasp of existing research in both academic and industry contexts and thus provide filtering criteria for further analysis. Second, a bibliometric analysis provides initial insights to the manually filtered articles specifically focused on the blockchain video games we are interested in. Third, a narrative literature review of the same articles is performed to contextualise the findings and provide deeper and more nuanced insights. The whole research workflow is summarised in Figure 1.

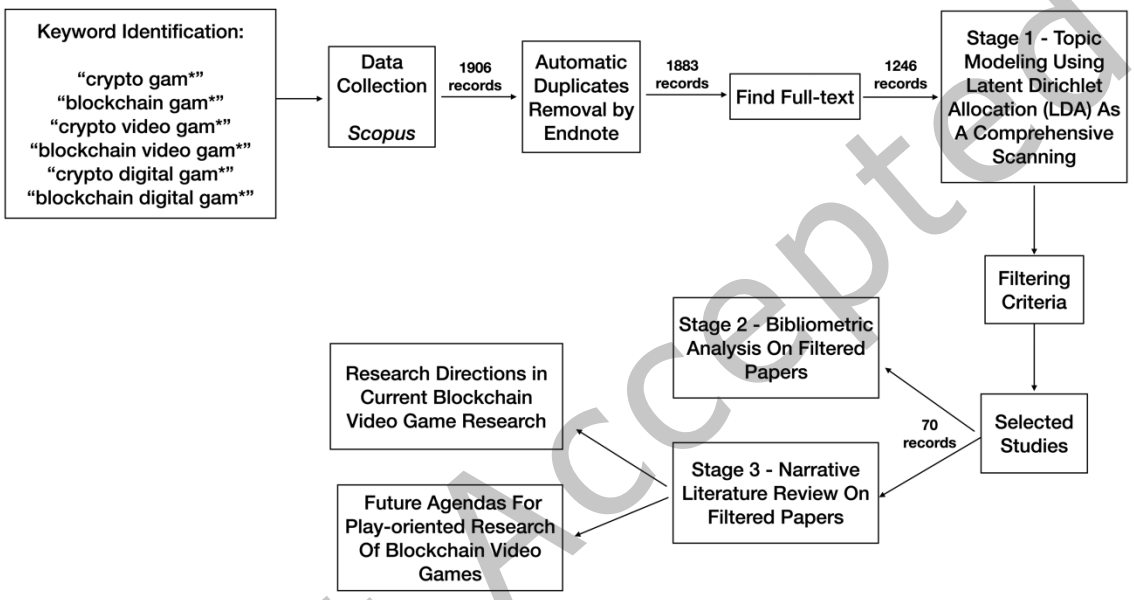


Figure 1: Workflow of Research Design

4 STAGE 1 - TOPIC MODELLING USING LATENT DIRICHLET ALLOCATION (LDA) AS A COMPREHENSIVE SCANNING

4.1 Methodology

Topic modelling is a statistical tool for extracting otherwise hidden structures and topics from large datasets. It is particularly well suited for use with text data [18, 19]. A "topic" is a recurring word pattern that frequently appears together. The topic modelling approach sees every document as a combination of various latent topics with different probabilities [20]. Through statistical techniques, it is possible to uncover these hidden topics by analysing the documents to reveal what topics each document embodies and with what probabilities [21]. Since we aim to provide a comprehensive positioning of the existing academic publications about "blockchain video games", topic modelling on the full text of these publications can provide helpful insights. Such an extensive analysis will help us to have an overall picture of the existing articles and allow us to narrow down to the exact articles related by suggesting possible filtering criteria.

4.2 Methods

4.2.1 Data Collection

We collect data by deciding the search strings, selecting the sources to search, and selecting inclusion and exclusion criteria. To generate the first wave of keywords related to a topic, Rowley et al. [22] suggest searching academic research publications, archives of magazines and newspapers, and industry publications. Inspired by pioneering reviews on blockchain and crypto games (e.g., [1, 14]) and media reports (e.g., [23]), the following keywords emerged: "blockchain gam*"; "blockchain digital gam*"; "blockchain video gam*"; "crypto gam*"; "crypto digital gam*"; "crypto video gam*."

Defining search strings leads to establishing the research data source. Scopus is chosen because it's the most comprehensive academic database in the world [24, 25]. Scopus also incorporates the results in other famous digital libraries (e.g. Digital Library, IEEE Xplorer and Springer Link). The comprehensiveness of Scopus can minimise the bias of results caused by the characteristic of the database itself (e.g., IEEE Xplorer itself may tend to index more papers on technology and engineering because of its specific nature). Also, in this way, Scopus can access data from many mainstream academic databases as possible. In total, 1906 records are returned from Scopus[4]. Duplications were automatically removed by Endnote[5], leaving 1883 records with their metadata. Among them, 1246 records have their full-text PDF files available for examination. These 1246 full-text PDFs are then put through LDA topic modelling to make the first step of exploration as broad as possible.

4.2.2 Data Analysis

There are several methods for topic modelling, but we use "Latent Dirichlet Allocation" (LDA) as applied in natural language processing [26]. LDA regards documents as generated from randomised mixtures of hidden topics, seen as probability distributions over words. Such generation is assumed based on a Dirichlet prior distribution [19]. LDA is one of the earliest and more frequently utilised topic modelling methods. It is a reliable approach and has succeeded- fully used in studies across various fields (e.g., social media, finance, and university teacher assessment) [27-29]. Therefore, we use LDA topic modelling to analyse the full text of screened articles, revealing the hidden topics. The Text Analytics Toolbox of MATLAB is utilised to conduct the LDA topic modelling in this paper as it's one of the most commonly used toolkits.

A typical workflow of LDA modelling includes the following phases: 1) collecting and importing the raw data expected to investigate; 2) cleaning the data through preprocessing (e.g., tokenise the text, lemmatise the words, remove punctuation, infrequent words, and remove stopwords). Tokenising the text means breaking down a sentence into every single element (e.g., "This game is good" is turned into tokens including "this", "game", "is", and "good"). Lemmatising means to reduce words to their base or root form (e.g., "better" and "best" are both standardised to "good"). Punctuation, stopwords ("the", "on", and "at", etc.), and infrequent words (i.e., words that appeared less than two times) are all removed. This preprocessing aims to remove the noise in the dataset and, hopefully, increase the quality of the models; 3) building the bag of words based on the cleaned data, i.e. breaking down the source material into smaller units for analysis. One can build the bag of words based on one single unit or combined units. A bag of words model can be made up of just a single unit which can be a single word (also called "unigram"), two consecutive words (also called "bigram") or more consecutive words). The model can also be made up of the mix of multiple units; 4) building LDA models from the bag of words with an a priori selected number of topics as a parameter; and 5) choosing the model(s) with the most suitable number of topics for more thorough interpretation and reporting.

In our case, the raw data is the full text of all the 1246 full-text PDFs converted into pure text (.TXT files) (Phase 1). These pure texts went through preprocessing (Phase 2). Based on them, five bags of words were built

4 The search string used in Scopus is "(TITLE-ABS-KEY-AUTH (blockchain) OR TITLE-ABS-KEY-AUTH (crypto)) AND (TITLE-ABS-KEY-AUTH (gam*) OR (TITLE-ABS-KEY-AUTH (digital) AND TITLE-ABS-KEY-AUTH (gam*)) OR (TITLE-ABS-KEY-AUTH (video) AND TITLE-ABS-KEY-AUTH (gam*)))"

5 Endnote is a reference management software in academics. References are stored in an Endnote library and can flexibly transform into different formats. Endnote client software supports finding duplicates in a library, namely records assigned the same reference type (such as Journal Article), and include the same information in the Author, Year and Title fields.

(Phase 3). There were three using single units (i.e., unigram, bigram and trigram) as these three may cover most terms in blockchain video games (e.g., “blockchain,” “blockchain chain,” “distributed ledger technology”). In addition to these three single bags of words, we built two combined ones. One is uni-bigram, the combination of unigram and bigram. The other is uni-bi-trigram, combining unigram, bigram, and trigram. These combined bags of words should be more meaningful representations of the published articles [30]. Combined bags of words are also recommended by some popular LDA modelling packages (e.g., the Python package ”Gensim”, which has been used in more than two thousand research papers and student theses [31]).

Eight topic numbers [5, 10, 15, ..., 40] were attempted following the best practice [32]. We chose these topic numbers to avoid too general topics emerging and also to allow reasonable manual screening of emerging topics across the models. Therefore, a total of 5 ∗ 8 = 40 models were built (Phase 4). Each model produced the following outputs: 1) The top 10 highest probability words of each topic and visualised as the word cloud; 2) The top 20 papers that have the highest probability in each topic (i.e., ”representative papers of each topic”); 3) Papers where one topic probability is the greater than any other topics’ probability; 4) The probability of all topics in the whole dataset; 5) The mixture of all topics’ probability in each paper. All the authors went through, discussed and reflected on all of these outputs in order to choose models with the most meaningful and interpretable topics for further analysis. Major results of the chosen models are reported in the Findings section. The workflow of our LDA modelling is summarised and visualised in Figure 2.

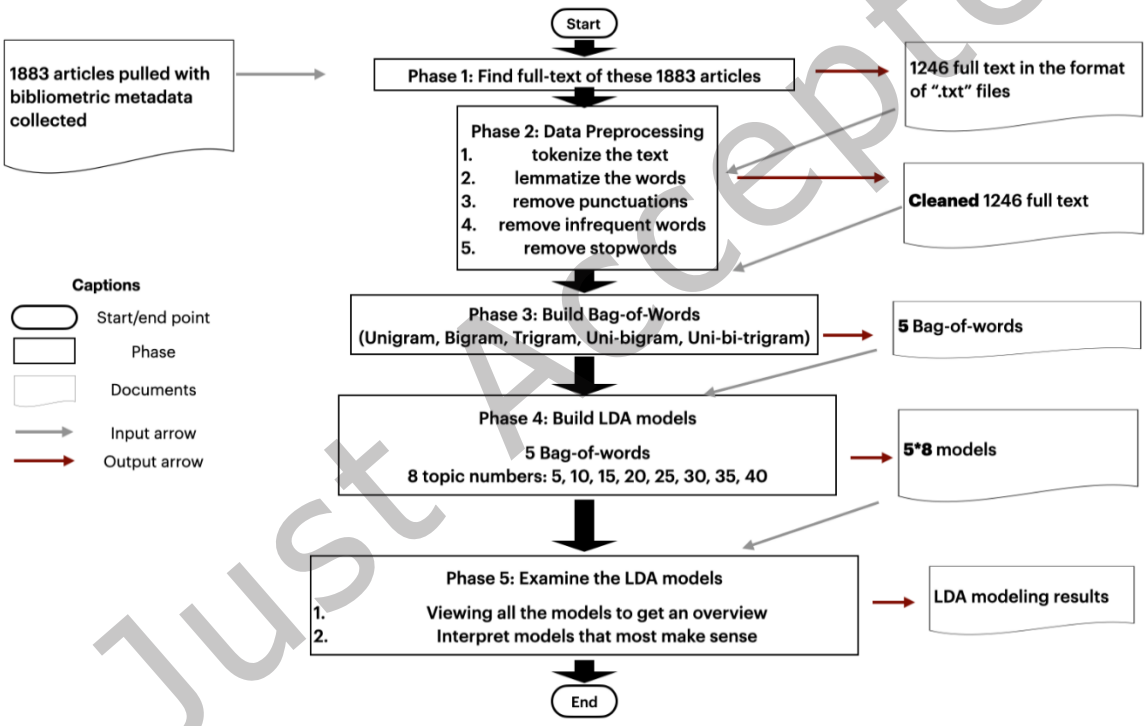


Figure 2: Workflow of Stage 1 LDA Topic Modelling.

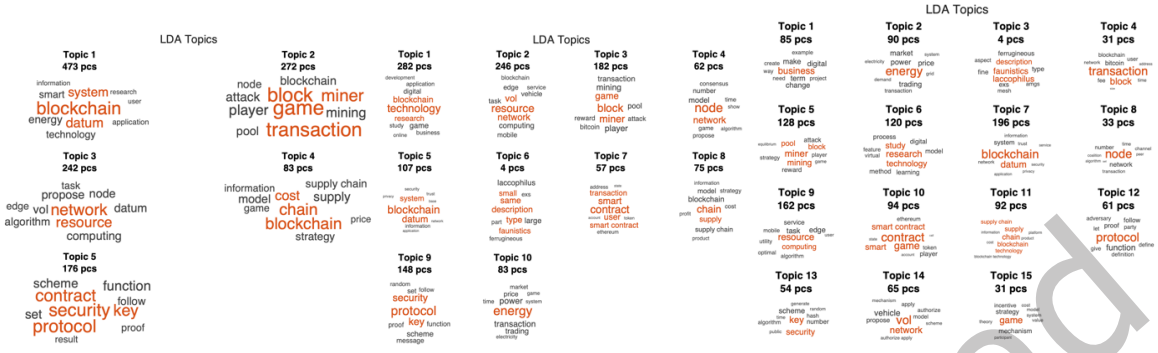
4.3 Findings

4.3.1 Overview

As mentioned, 40 LDA models were trained in this study, covering five bags of words and eight topic numbers. Due to space limitations, we will elaborate only on three representative models based on the bag of words of combined unigrams and bigrams. Readers can check our GitHub repository if interested in all the results[6]. Both authors independently went through all 40 models in order to choose the models whose topics make most sense

6 https://github.com/HughXuechen/BlockchainGameOverviewLDA

to human beings and have sufficient distinction between each model. After that, authors shared their idea on the models and picked up the mutually agreed models. The three models presented here are therefore selected as a trade-off between specificity and interpretability compared to other models. They are the "Uni-bigram, 5 Topics" model (Model A), "Uni-bigram, 10 Topics" model (Model B) and the "Uni-bigram, 15 Topics" model (Model C). The overview of the three models is presented in the word cloud figures in Figure 3.



(a) Uni-bigram, 5 Topics (Model A). (b) Uni-bigram, 10 Topics (Model B). (c) Uni-bigram, 15 Topics (Model C)

Figure 3: Word Cloud Figure of Three Exemplar Uni-bigram LDA Models.

One finding is that in all three exemplar models, "blockchain" always has its place in the topic where most papers reside (i.e., Topic 1 in Model A, Topic 1 in Model B and Topic 7 in Model C). This is not surprising since no matter of "blockchain video games" or "cryptogames," the enabling technology "blockchain" is crucial. Also, "blockchain" often co-appears with other terms related to technology (e.g., "datum," "system," "technology", and "network"), although human-centered terms like "user," "application", and "business" are not entirely absent. Therefore, although current discussions on blockchain video games still focus on technology, human factors have already emerged and have roles in topics.

Also unsurprisingly "game" frequently appears in the topics of the models (Topic 2 and 4 in Model A; Topic 1, 3, 4 and 10 in Model B; Topic 5, 10 and 15 in Model C). Among the top words in all the topics in the three models, "game" has the highest number of appearances except "blockchain." In topics like Topic 2 in Model A and Topic 15 in Model C, "game" is the representative word for the topic. At the same time, "player" also appeared in multiple topics in models (Topic 2 in Model A; Topic 3 in Model B; Topic 5 and 10 in Model C). Note "player" always co-appears with "game" in these topics.

To summarise, "game" and "player" seem to have already frequently appeared in the existing studies of blockchain games. Also, "game" and "player" always appear together in the topic models of blockchain game literature, which, again unsurprisingly, indicates that these two words have a strong correlation. These results could be interpreted that there is already tremendous play-oriented research on blockchain video games. However, a further manual analysis of "player" and "game" topics reveals that this is not necessarily the case. We need to investigate the papers more thoroughly and understand the specific meanings of "player" and "game" used.

4.3.2 Manual Analysis of "Game" and "Player" Topics in Stage 1

The manual analysis of "play" and "game" topics is facilitated by reading the top 20 representative papers of topics where "game" and "player" emerged as top words. As mentioned earlier, there are eight such topics (Topic 2 and 4 in Model A; Topic 1, 3, 4 and 10 in Model B; Topic 5, 10 and 15 in Model C). Each topic has 20 representative papers, namely papers with the top 20 highest probability belonging to this topic. After removing duplications, there were 149 papers left. The choice of 20 representatives may seem arbitrary. But in our case, data saturation (i.e., no new knowledge related to the research topic is added with additional data [33]) was reached within these 149 papers.

Among these papers, 113 (**75%**) don't mention any blockchain video games. Instead, they are the application of **game theory** and its related terms, including "evolutionary game", "stochastic game", "Stackelberg game", and "Nash equilibrium" (see [34, 35] as examples). Among the other 36 papers, 29 of them only mentioned

"blockchain" or "game." There are no practical elaborations on blockchain video games or players (e.g., [36, 37]). Three papers are not about blockchain video games but use games and gamification to teach blockchain concepts [38-40] and [41] is a proposal of making a blockchain video game to increase players' financial literacy but has no playable game prototype. Therefore, in fact, there are only three papers about blockchain video games with actual playable games. In the context of Axie Infinity, [42] speculates the potential of blockchain video games as NFT (Non-fungible tokens) games to empower the business in the metaverse and [43] shows a qualitative investigation of blockchain video game players. Finally, [44] reports the implementation of a web-based game prototype Co-De|GT for urban intervention.

To summarise, Stage 1 finds that the technological essence of blockchain has made "game" and "player" become frequently appeared words in the existing literature. However, they are not necessarily related to the blockchain video games and further filtering analysis of the literature is needed.

5 STAGE 2 - BIBLIOMETRIC ANALYSIS ON FILTERED PAPERS

5.1 Methodology

This stage aims at filtering out papers unrelated to our research goal and provides bibliometric analysis. The filtering criteria will be proposed based on the findings of Stage 1. After filtering the data, bibliometric analysis and LDA topic modelling will be conducted on these filtered papers supported by the software.

Bibliometric analysis involves the application of quantitative techniques to bibliometric data (e.g., citations, titles, and abstracts) [45]. Literature bibliometrics generally emphasises publication constructs [46]. It provides a structured way of reviewing literature in a broad scope that complements the traditional narrative literature review. Since the development of bibliometric software and scientific databases, bibliometric analysis has gained popularity in recent years [47]. As this study aims to show the general state of research on blockchain video games, bibliometric analysis is a good approach.

5.2 Methods

5.2.1 Data Collection

Results of Stage 1 indicate that the use of "game" and "play" in the existing blockchain video game context is seldom the same as we refer to "blockchain video games." Therefore, further filtering of our database is essential to have an overview of the specific blockchain video games (i.e., video games with blockchain technology [1, 2]). Table 1 shows the filtering criteria. Criteria I1, I2, E1 ,and E2 are adapted from previous literature reviews (e.g., [48, 49]). Acknowledging the findings of Stage 1, we require that the paper deals with at least one actual commercial blockchain video game or playable prototype to be included (I3). Similarly, the use of "game" must not be with the meaning of "game theory" or related terms (E3).

Table 1: Filtering Criteria

Inclusion Criteria	I1	The publication is an empirical, technical, or theoretical article.
	I2	The publication covers aspects of "blockchain" or "crypto." And it also includes "game."
	I3	There is an actual game/playable prototype in the publication.
Exclusion Criteria	E1	The publication is a technical manual detailing specific technologies.
	E2	Cryptogames/blockchain video games are not relevant to the publication (e.g., "cryptogames" or "blockchain video games" are mentioned, but there is no actual commentary).
	E3	"Game" in the publication is only used in the way of "game theory" and its variants instead of playable games.

Using the software MATLAB, papers whose abstract contains "game theory," "game-theor"(etic), "biform" (game), "coalitional" (game), "evolutionary" (game), "gap game," "Stackelberg" (game), "stochastic"(game), "signaling" (game), "Bayes," "sandwich" (attack), "Nash" and "equilibrium" are removed. Papers with other meaningless expressions of "game" (e.g., "game-changer") are also removed. Papers whose abstracts do not contain "gam" or "play" are removed. In this way, 383 articles are filtered out among the 1246 articles. Next,

two authors manually check the full text of these papers based on the filtering criteria. Only 70 articles remain, and the publication set is finalised.

The metadata of each selected study includes (1) citation information (e.g., author(s); document title; year; source title; source & document type); (2) Bibliographical information (e.g., affiliations, publisher); (3) Abstract & keywords (abstract, author keywords, index keywords). These data are exported into a file in the .bib format to facilitate analysis.

5.2.2 Data Analysis

Aria et al. [50], R Core Team [51] suggest using the Bibliometrix package supported by R Programming Language. Many publications use this package [48, 52, 53] and it supports Scopus .bib files making it suitable for bibliometric analysis. Among various metrics of bibliometric analysis, this paper reports two: word growth and co-occurrence network.

The top 10 words with highest cumulative frequencies so far are pulled out with a year-by-year breakdown of each word. By analysing word frequency change, we could notice what constructs authors most frequently mention in each year. Research focus trends may also be revealed by the dynamics of word frequencies. In our case, we are interested in the growth in authors' keywords. The keywords of a paper are usually the best indicators that convey the core concepts.

Co-occurrence means a relationship where two units appear together in an abstract. Units here can be words or sequences of words. Units and relationships can be visualised as a "co-occurrence network." In this network, each unit is a "node", and each relationship is an "edge." The size of the node corresponds to its frequency of co-occurrence. Table 2 introduces the two quantitative indicators used to measure co-occurrence relationships, betweenness, and closeness. The use of a keywords co-occurrence analysis and a visualised network to describe scientific fields has been used successfully in previous studies [54-56]. This type of analysis examines the relationship between basic pieces of information in text data. In particular, it connects the frequent occurrence of words in documents to create groups of terms that can be understood as different topics emerging in the scientific field.

Table 2: Indicators of Co-occurrence Analysis

Indicator	Definition	Meaning
Betweenness	Betweenness measures the number of times a node acts as a bridge along the shortest path between two other nodes.	Betweenness indicates the importance of one node for the existence of the whole network.
Closeness	1/(the sum of a node's distances to all other nodes)	The direct impact of one node on other nodes.

5.3 Findings

5.3.1 The Top 10 Words' Frequency Over Time

The top 10 words' (cumulative) frequency over time is shown in Table 3. The earliest paper we found (truly) related to blockchain video games is [57]. It investigated how to use blockchain to prevent cheating in multi-player online games in 2018. In 2019, multiple papers emerged using "ethereum," "game," "games", and "gamification" as the keywords. The year 2020 witnessed the first appearance of "cryptocurrency" and "smart contracts." In 2021, "nft" and "non-fungible tokens" had their debuts. The keyword which has the latest first appearance, "metaverse," came out in 2022. Almost every year, there are new keywords and concepts proposed in the field of blockchain video games. This indicates the strong vitality of this field.

Among all these ten top words in 2023, "blockchain" can be seen as a dominator as it has the most appearance compared with the words. It's reasonable to cluster "game," "games", and "gamification" into one group, and this "gam*" group have the second large count among other keywords. However, note that **there are no keywords like "play" or "player" in top 10 words.** Also, **there is no keyword like "design" or "game design."** Instead, concepts like "metaverse", "nft", "cryptocurrency," and "non-fungible tokens" have been heavily related to investment and finances in the previous years. Such a frequency distribution of keywords

may indicate that current blockchain video games and their research are interested in the technical and financial characteristics. The actual play experience, players' feedback, and design for playing seem to be lacking.

Table 3: The Top 10 Words' Frequency over Time

Year	2018	2019	2020	2021	2022	2023
blockchain	1	10	21	28	40	44
metaverse	0	0	0	0	8	9
cryptocurrency	0	0	1	3	6	7
ethereum	0	1	2	5	6	7
game	0	4	6	6	7	7
nft	0	0	0	1	6	7
smart contracts	0	0	1	2	6	7
games	0	1	1	2	5	5
gamification	0	1	3	4	5	5
non-fungible token	0	0	0	2	4	5

5.3.2 Co-occurrence Analysis

Table 4 shows the co-occurrence analysis results based on the authors' keywords, and Figure 4 shows the co-occurrence network generated. The analysis identifies 7 clusters in the chosen literature. Cluster 1, featuring "blockchain," dominates the entire network. As the absolute centre, "blockchain" connects to concepts specifically related to blockchain technology (e.g., "peer-to-peer" and "smart contracts") and other general ones (e.g., "framework" and "security"). Cluster 2 featuring "cryptocurrency" reflects the fact that blockchain video games may use cryptocurrency (supported by "smart contracts") as its incentive system for "pricing" and "cloud gaming." Cluster 3 only consists of "blockchains" and "behavioural sciences." Cluster 4 points out that the public frequently refers to blockchain video games (in the form of "browser games") using terms like "crypto games" and "crypto-games." It's frequently connected with "cryptocurrencies," "ethereum", "distributed ledger technologies (dlts)", and "gambling." Cluster 5 points out that "metaverse" and "nft" could be the instantiations of "attention economy" in this blockchain video game context. Cluster 6 points out that the blockchain video "game" is essentially a kind of "decentralisation" "software." Last but not least, Cluster 7 consists of only "art", which is loosely connected to Cluster 1 by "games." The co-occurrence analysis reinforces our assumption that current discussions on blockchain video games focus on technology (e.g., Cluster 1) and financial characteristics (e.g., Cluster 2 and Cluster 4). Play and players are, however, to some extent underrepresented in the existing literature.

6 STAGE 3 – NARRATIVE LITERATURE REVIEW OF FILTERED PAPERS

6.1 Research Design

A narrative literature review is a comprehensive, critical, and objective analysis of the current knowledge on a topic. It is often used in the early stages of research to establish a solid background for the research question and to identify gaps in the existing literature. Unlike systematic reviews or meta-analyses, which aim for a comprehensive and unbiased coverage of all relevant literature according to a predefined protocol, narrative reviews synthesize findings from a variety of sources in a more subjective manner. They allow the author to draw on their expertise and judgment to select the studies that they consider to be most relevant and significant [58, 59]. In our case, first, the authors familiarised themselves with the data, namely 70 shortlisted articles with full text. As a second step, both authors read these papers independently. Third, each author summarized the content of these articles in their own way and then shared it with each other. Finally, mutually agreed narratives are iterated and shown here as the findings.

Table 4: Co-occurrence Analysis Result

Node	Cluster	Betweenness	Closeness
blockchain	1	491.214	0.023
games	1	33.000	0.014
gamification	1	0.000	0.013
non-fungible token	1	0.000	0.014
non-fungible tokens	1	0.000	0.013
smart contract	1	0.000	0.013
serious games	1	0.000	0.013
dapp	1	0.000	0.013
framework	1	0.000	0.013
gaming	1	0.000	0.013
peer-to-peer	1	0.000	0.013
security	1	0.000	0.013
virtual economies	1	0.000	0.013
cryptocurrency	2	5.714	0.015
smart contracts	2	64.842	0.015
cloud gaming	2	0.000	0.014
pricing	2	0.000	0.014
blockchains	3	33.000	0.010
behavioral sciences	3	0.000	0.008
ethereum	4	99.000	0.016
browser games	4	0.000	0.014
crypto games	4	0.000	0.014
crypto-games	4	0.000	0.010
cryptocurrencies	4	0.000	0.014
distributed ledger technologies (dlts)	4	0.000	0.010
gambling	4	0.000	0.010
metaverse	5	28.981	0.014
nft	5	33.250	0.014
attention economy	5	0.000	0.010
value	5	0.000	0.010
game	6	0.000	0.014
decentralisation	6	0.000	0.014
software	6	0.000	0.014
application	6	0.000	0.014
art	7	0.000	0.009

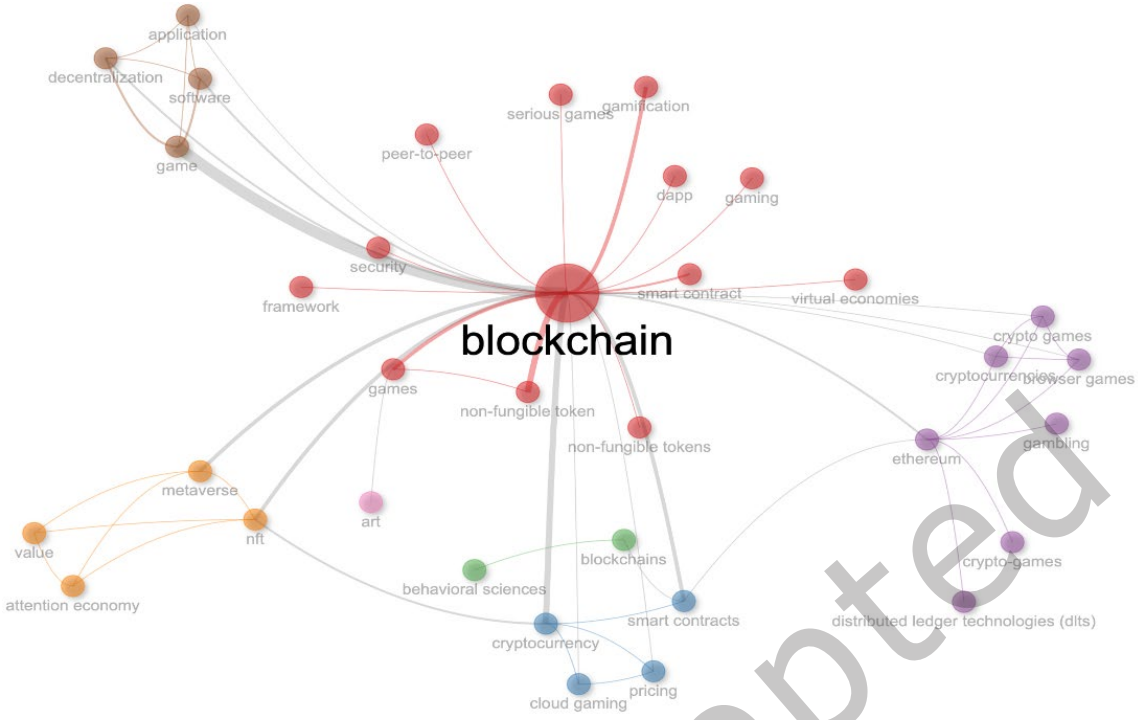


Figure 4: Network Plot of Keyword Co-occurrences Within the Blockchain Video Game Literature.

6.2 Findings

6.2.1 "Blockchain Video Games" – Definitions and Related Concepts

Blockchain video games have many terms and abbreviations. This study's shortlisted articles discuss blockchain video games, but few define them. Blockchain video games and related concepts must have a clear definition, especially in a non-technical way. Scholten et al. [14] define "blockchain gaming" as "any use of distributed ledger technologies like blockchains or cryptocurrencies in digital gaming and gambling." Blockchain is indeed a type of distributed ledger technology, but it is structured as a chain and uses a consensus algorithm (like Proof-of-Work in Bitcoin). So games using blockchain should use blockchain-specific ledgers. Accordingly, **blockchain video games** can be defined as games used in blockchain video gaming.

Cryptogames are closely related to blockchain video games, defined as "games whose allocation of in-game tokens is stored on a distributed ledger atop a cryptocurrency network" [14] or "games that use blockchain technology to provide additional value to their users or developers" [1]. "Blockchain games," "blockchain gaming," and "cryptogames" are used interchangeably without much clarification [14]. Blockchain's inherent technical structure may explain this interchangeability. Blockchain technology needs an incentive system to survive and continue. As a decentralised system, blockchain is not maintained by a fixed centre. In order to encourage participation, **coin** rewards are incorporated into the blockchain system. Thus, coins are native to blockchains. Every crypto coin runs on its blockchain [60, 61]. As a result, a blockchain and a coin that encourages maintenance are intertwined. Because blockchain systems allow coins to circulate and become "currencies," they become **cryptocurrency**. This "blockchain – coin – cryptocurrency" system is an electronic payment system with Bitcoin system as an example, and it is considered the first-generation blockchain [62, 63].

Ethereum was born in 2015, enabling transactions on the blockchain to be programs. **Smart contracts** are programs stored on a blockchain that run when predetermined conditions are met. Programs like these can, for example, boost retailer-supplier trust [64]. Smart contracts cost money to deploy and execute. To fuel smart contracts, the coin is used. Smart contracts can create tokens (i.e., digital representations) directed to specific objects. Tokens that are directed to different specific objects are called non-fungible tokens (**NFTs**). As

blockchain networks guarantee strict uniqueness, NFTs can be linked (or "minted" by the industry) to digital works of art. Once NFTs are accepted by the market, they become digital collectibles. This “smart contract-NFT-digital collectible” relationship marks the second generation of blockchain. Figure 5 illustrates blockchain and related concepts. Currently, there is a lot of research emerging on NFT games as they form a large portion of current blockchain video games.

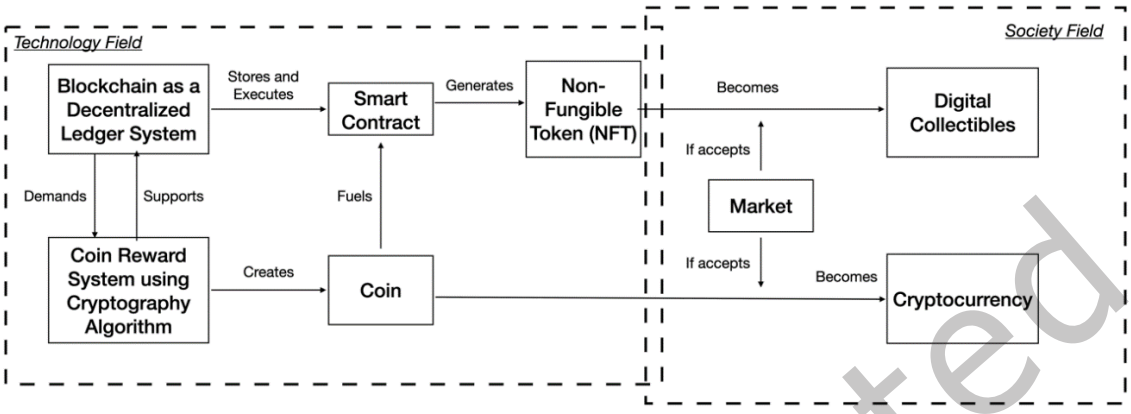


Figure 5: Relationships Between Blockchain and Related Concepts.

6.2.2 Two Types of Current Blockchain Video Games

Type I – Blockchain Video Games as the Extension of Traditional Games with Digital Assets

Type I blockchain video games adopt the most significant value proposition of blockchain, namely digital assets. Blockchain technology ensures immutability, providing a sound certificate for digital content's uniqueness. Uniqueness can create value in digital content and turn it into an asset. Today's digital assets are stored on blockchain networks instead of game servers, unlike in pre-blockchain days. Players own digital assets. Consequently, blockchain makes the player "the real owner of virtual assets" [65, 66] and “automatically get royalties of virtual assets,” including the user-generated contents (UGC) [67].

Traditional video games can benefit from digital asset realisation with a blockchain network. Figure 6 shows this kind of architecture. The blockchain network in this type of blockchain video game does not affect most gaming sessions. Player interactions are handled by the traditional server network except for virtual assets. In most cases, a blockchain network suspension will not affect players. Interruptions will only affect those dealing with the virtual asset.

Type I games may appear in various genre regarding the gameplay. To name a few: CryptoKitties is one of the most famous collectible games. Axie Infinity is an idle strategy game. StepN[7] is a fitness game enabling players to run in the real world and earn rewards. More traditional game genres are expected to have their blockchain video game versions.

Type II – Blockchain as a Game Infrastructure

Type II blockchains video games use blockchain as an infrastructure to provide additional benefits to players. Transactions on the blockchain are immutable, open, and peer-confirmed. Game servers are protected from cheating and Distributed Denial-of-Service (DDoS) attacks [69]. Additionally, blockchain can provide long-term storage of gaming data [70] and free developers to create specific features for transactions (e.g., trading) [67].

Proofs-of-concept have been done previously. The Ethereum blockchain network can be used, for example, in multiplayer games for game award transactions [71, 72]. Due to the differences between money transactions and play moves on the blockchain, Kraft [73] proposed a mechanism to differentiate them efficiently. Recently, a game named Dark Forest[8] has been entirely facilitated by smart contracts. In this way, the blockchain network keeps the game running. The game has the potential to provide an independently-lasting game world [74, 75].

7 https://stepn.com

8 https://zkga.me

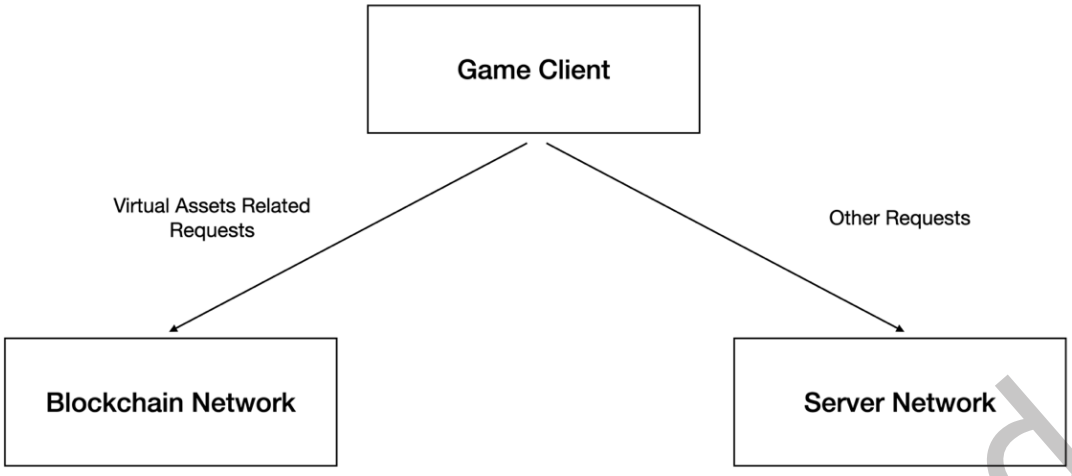


Figure 6: Blockchain Video Games as the Extension of Traditional Games with Digital Assets [68].

Compared to Type I games, blockchain technology is now an integral part of Type II games. If the blockchain network is suspended for several minutes, few Type II games might work well. It would greatly impact the general playing experience.

According to this review, blockchain has no significant impact on gameplay at this moment in blockchain video games. Blockchain enables digital assets in Type I games. Blockchain provides an information infrastructure for Type II games. Yet, blockchain has not significantly impacted players' direct playing experience.

6.2.3 The Playability Problem - Lack of Player Feedback

As one kind of game, blockchain video games are supposed to be playable. Blockchain video games, however, generally lack interactivity, have simple rules, and have short lifespans [66, 73, 76]. None of the papers reviewed in this study explained their game design choices (e.g., why make a blockchain adventure game instead of a first-person shooter). Playability and gameplay are minimal in both current blockchain video games and research about blockchain video games. [2, 5, 77].

This playability problem has several causes. First, technology constraints. 1) Blockchain transactions are slow and unstable. Players must wait until all transactions are complete, according to the block interval time [78, 79]. This puts a strict limitation on gameplay that demands intense interactions; 2) The volume of game data stored in the blockchain network can be enormous. Blockchain nodes must store network data since it is a distributed storage system. There is little storage space left for a rich game design, and game developers' design space is substantially reduced [5, 67, 77, 79]. Secondly, blockchain technology is difficult. Even generating a random number in typical casino games can become a new challenge in the blockchain context [80, 81]. Players may also have difficulty understanding all the terms and steps needed to play blockchain video games (e.g., linking a crypto wallet to the game) during the initial stages of blockchain adoption [5, 80]. Therefore, game developers face challenges. Thirdly, many blockchain video games are just proofs-of-concept as minimum viable prototypes for whether business or technical purpose. Playability design doesn't take much place in the process.

There is also little player feedback on blockchain games. As an example, Table 5 summarises the blockchain games mentioned in the articles reviewed in this study based on players' feedback. In the papers reviewed, 50 blockchain games are mentioned. Most papers focus on technical evaluations of games, such as speed, accuracy, and transaction success rate (e.g., [71]). Other important factors are gamers' safety, privacy, and response time [5, 66, 82]. Of these games mentioned, only seven (14%) have player feedback (bolded in Table 5). It is essential to know how blockchain games are experienced by players by reading their comments. Blockchain video games are played for both utility (e.g., digital asset speculation) and enjoyment, according to Gao et al. [77]. Research shows that blockchain video games are not just speculative investor hype. Fun and engagement still exist in blockchain video games and are worth further investigation.

Table 5: Blockchain Video Games Appeared in the Reviewed Articles

No.	Name	Year	Category	Player Feedback	Reference
1	Satoshi Dice	2012	Commercial Game	No	[83, 84]
2	Dragon's Tale	2013	Commercial Game	No	[84]
3	Mythereum	2015	Commercial Game	No	[85]
4	**CryptoKitties**	**2017**	**Commercial Game**	**Yes (see [77])**	**[9, 43, 77, 86-98]**
5	Etheremon	2017	Commercial Game	No	[83]
6	Spell of Genesis	2017	Commercial Game	No	[99]
7	0xUniverse	2018	Commercial Game	No	[83]
8	**Axie Infinity**	**2018**	**Commercial Game**	**Yes (see [43])**	**[43, 89, 100]**
9	BetDice	2018	Commercial Game	No	[83]
10	CardMaker	2018	Commercial Game	No	[83]
11	**Cell Evolution**	**2018**	**Commercial Game**	**Yes**	**[83, 101]**
12	EOS Knights	2018	Commercial Game	No	[83]
13	EtherGoo	2018	Commercial Game	No	[83]
14	FarmEOS	2018	Commercial Game	No	[83]
15	FOMO 3D	2018	Commercial Game	No	[83]
16	Gods Unchained		Commercial Game	No	
17	KittyRace	2018	Commercial Game	No	[83]
18	KotoWars	2018	Commercial Game	No	[83]
19	Pandemica	2018	Commercial Game	No	[83]
20	PoWH 3D	2018	Commercial Game	No	[83]
21	TRONBet	2018	Commercial Game	No	[83]
22	Adam's Adventure (AA)	2019	Playable Prototype	No	[102]
23	Adam's Venture	2019	Commercial Game	No	[83]
24	Crypto Space Commander	2019	Commercial Game	No	[83]
25	Eco Parking	2019	Playable Prototype	No	[83]
26	EOSDOTA	2019	Commercial Game	No	[83]
27	EOSFomo 3D	2019	Commercial Game	No	[85]
28	EOSlots	2019	Commercial Game	No	[83]
29	HyperSnakes	2019	Commercial Game	No	[83]
30	Last Trip	2019	Playable Prototype	No	[102]
31	LuckyBit	2019	Commercial Game	No	[83]
32	Rhythm Dungeon	2019	Playable Prototype	No	[103]
33	Untitled	2019	Playable Prototype	No	[104]
34	Untitled	2019	Playable Prototype	No	[105]
35	**Bloxxgame**	**2020**	**Playable Prototype**	**Yes**	**[106]**
36	Decentraland	2020	Commercial Game	No	[107]
37	Lithopia	2020	Playable Prototype	No	[108]
38	MOATcoin	2020	Playable Prototype	No	[109]
39	Untitled	2020	Playable Prototype	No	[110]
40	Watergame	2021	Playable Prototype	No	[111]
41	Widow Waterfall	2021	Playable Prototype	No	[112]
42	**Avaegotchi**	**2022**	**Commercial Game**	**Yes**	**[113, 114]**
43	**Blockchain-Enabled Beer Game" (BEBG)**	**2022**	**Playable Prototype**	**Yes**	**[80]**
44	Co-De|GT	2022	Playable Prototype	No	[44]
45	Dark Forest	2022	Commercial Game	No	[115]
46	Tanks	2022	Playable Prototype	No	[87]
47	Untitled	2022	Playable Prototype	No	[116]
48	Aegis	2023	Playable Prototype	No	[117]
49	R?ddle	2023	Playable Prototype	No	[118]
50	**Tourism Destination Serious Game (TDSG)**	**2023**	**Playable Prototype**	**Yes**	**[119]**

6.2.4 Lack of Critical Review on Blockchain Video Games.

Critical reviews reveal the assumptions, values, ideologies, and behaviour norms that influence everyday life [120]. Blockchain video games link blockchain technology, finance, organisations, and video games. Each of these elements may have its specific assumptions and values embedded, and they have made great impacts to the human society in various aspects already. Therefore, blockchain video games should be subject to critical review. Nevertheless, only a limited amount of critical analysis of blockchain video games is found in the existing literature. For example, Serada [121] discussed how a "Fair Price" can be made in blockchain video games (e.g., CryptoKitties). Such an fairness in blockchain video games is said to be guaranteed by the slogan "code is law," namely code will be strictly executed without any blur in transactions made on blockchain network [122]. This alleged fairness given by code and blockchain network resonates with recent heated discussions about the algorithm justice [123, 124]." There is also comment that blockchain is not only about "fairness," but also about "value," "ownership," and "scarcity." Thus, blockchain video games create a "new ludic economy" based on digital games [9].

These pioneering discussions are highly significant and relevant. There still is, as indicated by the literature review, an insufficient amount of critical reviews on blockchain video games despite the rapid diffusion of blockchain technology into video games.

7 DISCUSSION

With the heated debate over blockchain video games and the general crypto industry, blockchain video games are an important opportunity for game developers and technology advocates. Nevertheless, recent failures in the blockchain video games, such as depreciation in the game-related collectible assets and a significant drop in player activity, remind people that blockchain video games are still a long way from becoming a true "game-changer" in the game industry [6-8].

The purpose of this overview study is to serve as a stepping stone for further discussions in blockchain video games. We utilise bibliometrics analysis and narrative literature review to provide comprehensive knowledge. Currently, blockchain video games come in two types. Academics primarily focus on blockchain video games' technical aspects or financial applications. A field of research has emerged from blockchain video games, closely related to other blockchain concepts (mostly recent NFT and metaverse).

Blockchain video games have adequate technology-oriented research, investigating various technical solutions. Furthermore, blockchain video games are being researched in the cryptocurrency and so-called decentralised finance industries. Nevertheless, this overview study indicates that blockchain video games have insufficient play-oriented research. This play-oriented research should address the playability problem of blockchain video games [5], understand the game design of blockchain video games and make critical reviews on blockchain video games. Given these findings, the following future research agendas are proposed.

7.1 "Move Forward from CryptoKitties" – Blockchain Video Games in More Types and Genres

CryptoKitties is unquestionably one of the most iconic blockchain video games [5]. CryptoKitties gained huge popularity shortly after its release, affecting over 10% of Ethereum traffic in early December 2017 [125]. A total of 340,000 Kitties have been sold, and more than $25 million has been exchanged in 2018 [126]. Nevertheless, CryptoKitties is only one example of Type I blockchain video games identified in this study. It's only one example of video games using blockchains for digital assets. The gameplay of CryptoKitties is simply collecting and trading. Type I blockchain video games are now being developed in different genres, such as fitness, role-playing, and music action games. This future direction is in line with the blockchain video games research opportunities call made by Arnedo-Moreno et al. [65]. Different genres of gamers may have different expectations and experiences when playing blockchain video games and especially when engaging with the blockchain component.

Type II blockchain video games are also emerging. For these games, blockchain is still limited to the communication layer of game infrastructure and limited to certain kinds of games (e.g., strategy games). And most of these games are solely built on the Ethereum blockchain network. It is promising to see what blockchain technology can bring for player's experience instead of merely as a game infrastructure. Also it would be

meaningful to examine how different blockchain network settings (e.g., different consensus algorithms) may impact the game.

Last but not least, we are expecting “Type III” blockchain video games to emerge in the future, namely games that have affordances that are uniquely enabled by blockchain video games. These kinds of games may also be called “native blockchain video games.” Currently, a blockchain video game may still fall into the game genres (e.g., strategy game or role-playing game) and their gameplay do not necessarily need blockchain technology. Instead, the Type III blockchain video games may demonstrate a unique gameplay that blockchain technology can only enable. We think this Type III blockchain video game will be the full demonstration of blockchain technology’s potential in the game industry.

7.2 Blockchain Video Game Design Pattern Analysis

Design patterns describe the practices involved in a design. It describes the solution to a problem that repeatedly occurs in design activities. Anyone can follow the solution without re-proposing it [127]. Robust applications use patterns for two reasons. Existing patterns are often verified by others. Thus, these patterns could be reused. Pattern design is a common language for developers and designers. The use of design patterns facilitates communication. The design pattern approach is widely accepted in both programming and interaction design [128, 129].

Kreimeier [130] introduced the design patterns approach to digital games. Later, the patterns approach was generalised to fit all games by Björk and Holopainen [131]. Their initial collection of nearly 300 gameplay design patterns in 2004 has expanded to more than 600 in 2022 [132]. Game designers use these patterns to guide their work. However, there are still no specific patterns for blockchain video games. Six et al. [133] discussed design patterns for decentralised applications. The findings suggest "on-chain patterns" and "on/off-chain interaction patterns" to consider when developing decentralised applications. The findings are valuable but not specific to blockchain video games.

In a play-oriented context, such a blockchain video game design pattern analysis and catalogue might be worth investigating for further development of blockchain video games. Three aspects may be considered in blockchain video game design pattern research: 1) how previously discovered game design patterns perform in blockchain video game context; 2) what new game design patterns emerge from blockchain video game practice specifically; and 3) what guidelines are provided for blockchain video game design.

7.3 Know More About Blockchain Video Game Players

According to this study, blockchain video game players have hardly been heard in academic discussions. A play-centric game design approach suggests collecting feedback from players after their playtests and iteratively modifying the game [10]. In order to understand players' experiences of blockchain video games, researchers may use established methods [134] such as surveys, interviews, observations, and think-aloud protocols. Machine learning algorithms for clustering players can be helpful since blockchain transactions have open and accessible data by nature [135].

Researchers can conduct longitudinal studies on blockchain video game players' interactions and metrics of the game to see how they change over time. For example, Jiang et al. [5] found that the transactions in CryptoKitties surged to a peak after the game’s release but dropped drastically and quickly. Many players quit the game. Most of the revenue in the game is controlled by a small group. Research could examine whether the same process applies to other types of blockchain video games. In particular, the role of blockchain could be addressed in the flow of interaction between players and game interfaces. When do players encounter or seek interaction with the blockchain module in the game? How do they feel about it? Such questions are expected to find out what’s specific among the blockchain video game players and game designs.

7.4 More Critical Reviews on Blockchain Video Games

The media and investors have hailed blockchain technology as a disruptor, transformer, and "game changer" in the game industry [136-138]. Indeed, blockchain has brought new value propositions, such as digital assets and rule transparency, to the game industry. Furthermore, blockchain technology introduced a decentralised infrastructure to video game systems. Blockchain video games of Types I and II illustrate these two

contributions. However, blockchain technology has not yet contributed directly to gameplay, as stated in this study. Players must cope with the current constraints on game transaction speed, transaction stability, and complex knowledge to understand blockchain video games. Additionally, blockchain technology has an environmental impact on carbon emissions and energy waste due to its proof-of-work algorithm [139, 140]. Therefore, blockchain advocates should at least tone down their enthusiasm for blockchain video games.

Meanwhile, blockchain video games and the industry need a critical review. Blockchain video games push issues of value, fairness, and the relationship between playing and working in the game industry to the forefront [9, 141]. An ironic observation is the role of **platforms** in the current blockchain video game industry. Blockchain is fundamentally a peer-to-peer network featuring decentralisation. However, blockchain players rarely have access to the game without platforms. To name a few, players buy cryptocurrency to play the game at crypto markets like Coinbase[9]. The purchased cryptocurrency will be imported into the players' wallets by platforms like MetaMask[10]. Once the players get the digital collectible in the game and want to sell them, they usually put these digital assets on exchanges like OpenSea[11]. In the context of blockchain, why do these platforms emerge? What are the impacts of these platforms on the blockchain video game industry and players' engagement? What implications does their behaviour have for classic video game critical reviews? Researchers interested in blockchain video games could explore these questions in more detail.

8 CONCLUSION

Blockchain video games combine blockchain technology and video games. Blockchain video games are unmissable because of their business impact and technological novelty. Current academic discussions of blockchain video games have developed and explored technical solutions, differentiated core concepts, and identified two types. Still, blockchain video games lack playability, and this problem is rarely addressed. The players weren't heard enough. Blockchain video games don't get critical reviews. As a result, this paper proposes four directions for future blockchain video game research: 1) Explore blockchain video games in more types and genres; 2) Bringing in design pattern analysis of blockchain video games; 3) Know more about blockchain video game players and 4) Include more critical reviews on blockchain video games. Blockchain video games can serve as a pretext for the diffusion of blockchain technology in other creative media, and breakthroughs in the above mentioned four directions are expected to propel the general adoption of blockchain technology in the creative industry.

This paper serves as a starting point for blockchain video games research. Still, it has limitations. First, the volume of articles reviewed is small. There may be several reasons for this. Blockchain is already a hot research field, but blockchain video games are relatively new. Therefore, blockchain video games studies are scarce. Another reason could be that this study only looked at Scopus. Despite being the largest academic database, there should be more meaningful articles not indexed there. Those articles may be sorted carefully and integrated into reviews in the future. Second, a machine-supported analysis on the full text of filtered papers (e.g., LDA topic modelling on these papers' full text) could have been reported besides the narrative literature review conducted in this paper. Actually, we have already done the modelling and have some results. Limited to the length of the paper, we decided to omit that part and leave it for the following study. Third, the paper does not offer a detailed gameplay analysis due to space limitations. Playability is only explained, and research directions for game design patterns are pointed out. Fourth, this paper only provides a brief discussion of recently emerged concepts related to blockchain video games (e.g., NFT and metaverse). In fact, each of them has already become a topic worth discussing from various aspects. This paper intends to reveal the connections between blockchain video games and these topics instead of providing details on each topic. Future studies are

9 https://www.coinbase.com

10 https://metamask.io

11 https://opensea.io

encouraged to dig deeper into these connections. For example, it would be interesting to see how blockchain video games are connected to NFT in terms of gameplay, technology framework and financial intensives.

We plan to provide a deeper understanding of the game design by analysing the existing blockchain video games in the following study. Still, future research could build upon this study to provide a comprehensive understanding of blockchain video games.

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