On the Understanding of Gamification in Blockchain Systems

Reza M. Parizi
Department of Software Engineering and Game Development
Kennesaw State University
Marietta, GA 30060, USA
rparizi1@kennesaw.edu

Ali Dehghantanha
Department of Computer Science
University of Sheffield, UK
a.dehghantanha@sheffield.ac.uk

***Abstract*—Blockchain is a new trend rising fast from the community and the enterprise world. As an infrastructural technology it is finding its way into a growing number of domains like finance, medical, digital marketplace, pharmaceutical and government agencies. While blockchain technology is primarily thought as the foundation of Bitcoin, it has grown far beyond underpinning the virtual currency. It promises building better trust, transparency, and integrity without a third-party and the risk of censorship. These remarkable advantages do however come at a price. The blockchain ecosystem is riddled with human-centric and economical issues for its participants, leading to unintended consequences in decentralized networks. Gamified software engineering is a growing field that in particular taps into gamification technology, the application of game mechanics in non-game contexts, to address human-related concerns. There are currently no studies around blockchain that have been identified to have a clear view of existing research and solutions for utilizing the gamification in the emerging blockchain systems. As a first step towards filling this gap, this paper discusses and identifies two major human-based problems in the blockchain decentralized applications and development. For those problems, it proposes a preliminary gamified model to provide a basis for expanding future research and applications in this joint domain.**

Keywords—Decentralized software development, Blockchain, Smart contracts, Decentralized applications, Gamification, Peer-to-peer networks

I. INTRODUCTION

Blockchain represents a paradigm shift from centralized to decentralized computing, and it is a fast growing field in both academia and the enterprise world. The introduction of Bitcoin protocol by Satoshi Nakamoto [1] in 2008 has marked the beginning of this new era of decentralization in software systems worldwide. Following a ten-year time of incubation, the more far reaching variant of technology is getting more attention for a possible range of applications in different industries, including security, finance, medical, digital marketplace, pharmaceutical and government agencies. One of its attributes of being third-party independent makes the blockchain technology a first choice for innovative business models and startups. So far, the emphasis on advancements around blockchain has been for the most part, the domain of innovators and early-adopters. Although the developments in the field is closely observed by the academia, there is relatively little research forums concerned with the human-related issues in the blockchain systems and its ecosystem. Among others, sustainability has been the main shortcoming of decentralized blockchain systems (especially in cryptocurrency areas) when active participation and engagement by involved users is the major concern, diminishing the stability and usefulness of such systems.

Gamification [2], [3] has been trending for the recent years and it is popular with both individuals and organizations in the online world. The idea of adding game-like features on enterprise information systems [4], [5], web and mobile apps [6], IoT apps [7], [8] has been more and more recognized by leaders, companies, and developers. At its core, gamification seeks for improvement of the user's engagement, motivation, and performance when carrying out a certain task, by means of incorporating game mechanics and elements, thus making that task more productive [9]. In fact, we have seen the widespread use of gamification in the real world today in the realms of learning, business and even the routine aspects of lifestyle. For instance, the privileges of online shopping with credit cards, social media (e.g. Linkedin progress indicator or endorsement buttons), e-learning environments (e.g. Code Academy that uses a motivational system of various game mechanics to keep learners engaged and incentivized to continue learning), mobile apps, and many more. Hence, gamification potentially makes any technology more inviting by virtue of users' engagement to desired behaviors. This is why a wide range of industries has turned to gamification and the use of game design principles to maximize user's involvement and minimize customer churn. In this respect, the idea behind gamification can be worthwhile and attractive regarding human-related problems in the blockchain technology. Inspired by this, this paper hence investigates the application of gamification in the blockchain space by discussing the current problems and possible areas that gamification would make sense to use. The paper aims at providing a starting forum for addressing the human-centric challenges arising from this new technology and the "how to" of gamifying a blockchain system can fundamentally change how better business value is created and realized. This work primarily addresses researchers to the discipline in order to shed light on future directions of research and practices in the gamified blockchain field.

The rest of this paper is structured as follows: Section II presents the related work on the application of gamification in software and system engineering tasks and provide necessary background on the blockchain components. Section III identifies human-centric problems in blockchain systems and

978-1-5386-7810-7/18/$31.00 ©2018 IEEE
DOI 10.1109/W-FiCloud.2018.00041

outlines the proposed gamified model. Section IV discusses the aspects related to game mechanics and a preliminary list of suggested ones for blockchain systems. Section V gives the conclusion and future work.

II. Current State of Research and Background

This section presents the related work either in terms of R&D studies that support tailoring gamification into various software engineering activities (Section II.A), or in terms of market products/projects that combine the gamification and the blockchain capabilities for building gamified environments (Section II.B).

A. Gamification in Software Engineering

While education industry [10], [11] has been a huge supporter of the gamification technology in learning [12], [13], [14], it has also been widely advocated by many studies in the software engineering domain to mitigate human-centric issues in various level of software development and maintenance. Software engineering is inherently a human-centric and collaborative process in a quite volatile environment. This nature in turn makes the gamification a good fit to improve the daily engagement and motivation of software engineers in their tasks. Seen it this way, gamification can be realized as a remedy to unlock motivations of the currently unengaged software engineering-related concerns/ problems.

Over the past recent years, the software engineering community has seen a tremendous interest in relating the gamification to the field and beyond. An examination of the literature reveals that gamification has been utilized across various directions and applications, aiming at the enhancement of conventional techniques or processes. For instances, in requirements elicitation [15] and prioritization [16], software traceability tasks [17], [18], software testing [19], software processes [20], [21], project management [22], and knowledge sharing [23]. The results achieved from these works and similar framework-driven [9], [7] and experimental [24] studies motivated the use of gamification and its usefulness within software and systems engineering activities.

B. Blockchain for Gamified Environments

There are very few cryptocurrencies and platforms that aim at leveraging blockchain for providing better gamified solutions. HoToKeN [25], Sandblock [26], and POINTToken [27] are three examples of such systems to manage rewards and loyalty programs on the blockchain. In this kind of works, proposers justify that the blockchain capabilities have the potential to transform how businesses incentivize and engage customers in loyalty programs and gamification initiatives. One of the common criticisms highlighted against centralized loyalty programs is that they are mainly designed to maximize profit for companies, most oftenly making it difficult for participants to be fairly rewarded for their efforts and the amounts they spend. In this regard, the aforementioned systems promise to bring the benefits of the blockchain (such as secure records, transparency and transactions using crypto tokens) to closed and centralized systems of rewards and loyalty programs, where a unified on-chain ledger will be globally holding rewards and points (representing the blockchain's assets) across multiple vendors, providers, and end-users.

While these works claim that the blockchain technology could bring gamification and rewards to every industry, their downsides can be summarized in twofold: (1) the blockchain is primarily not a good choice to store large amounts of frequently updated data, such as rewards or points. For the most part, these blockchain-based gamified systems encourage migrating from a centralized database that is currently managing a gamification system (handling badges, points, reputation, etc.) to a decentralized publicly ledger on top of a blockchain. But, it has to be said that in case of migrating from a centralized system (database) to a decentralized public blockchain, the resulting system will be significantly slower in terms of throughput, and will be more expensive than centralized existing system, as every state-altering transaction requires a cost of payment for the verification by the network; (2) the lack of understanding that the blockchain applications are themselves have core gamified issues that should be resolved first before then can be used for any loyalty simulation or rewards system (which is the main focus of this paper).

On the other hand, there are also very few startup blockchain-supported projects that are trying to incorporate game-like concepts in their business models. Arcade City [28] is a ride-sharing blockchain-based system that claims to solve the issue of decentralized reputation through opt-in gamification layers. They borrowed the concept of *levelling up* the driver or rider profile from role-playing games. Drivers level up their profile by providing safe and enjoyable customer experiences. The rules governing the provision of points were driven by community consensus and built as smart contracts on the Ethereum [29] blockchain.

FundFantsy [30] is another new blockchain project that offers a simplified version of the trade based on the Ethereum platform [29], which allows investors to become players and compete with other players to win a prize. Their proposed idea was inspired by the principle of fantastic sports that enables users to open their own contests and invite their friends to win part of the prize pool.

In summary, our literature study shows that there is currently a lack of research work to investigate various aspects of the blockchain decentralized technology in tandem with the gamification technology, and how it can be used to improve the human-related concerns in this emerging technology. As a start point, our work in this paper takes the first step by facilitating discussions, aiming to pave the way for conducting further theoretical and empirical research in a more community-wide software engineering infrastructure.

C. Background on Blockchain Components

Blockchain technology is not just only one single technique. It integrates a multi-field infrastructure including cryptography, distributed consensus algorithm, economic model, and peer-to-peer networks. A blockchain can be seen as constituted by:

1. A strategy for creating an unalterable ledger, *by* and *for* all participants in a broadcast network.
2. A strategy for expressing consensus as ledger entries, i.e., validating transactions.
3. A strategy to incentivize consensus.

The use of a broadcast network is to ensure that all participants in the blockchain process the same sequence of signed transactions (most blockchain networks use elliptic curve digital signature algorithm (ECDSA) [31] for this purpose). Each transaction triggers execution of a well-defined process. The result of the process triggered by a transaction is a state-change in the information system represented by the blockchain.

The security strength promised by a blockchain network stem from the fact that anyone can audit the entire history of all states of the system. In practice, that anyone can audit does not necessarily imply that everyone will. It is for this purpose there exists a special class of users/nodes, known as *miners* in Proof-of-Work consensus methods or *minters* in Proof-of-Stake methods, who are incentivized to verify the correctness of every transaction (including block/contract-creation and state-change transactions).

The incentive in blockchain systems can be direct – in form of *Proof-of-Stake (PoS)*, or indirect – in form of *Proof-of-Work (PoW)*. In PoW based method (Bitcoin uses Hashcash proof of work system), miners are to solve a puzzle, which is an advanced mathematical problem. In this step, a miner node on the P2P network is calculating advanced mathematical problems with the goal of finding the ID for the next block of the blockchain. This calculation needs the ID of the previous block to calculate the ID of the next block, and this makes the blockchain immutable since if someone wants to change a block he needs to calculate the ID of every previous block. Each node participating in the proof-of-work consensus competes in solving the mathematical problem. The first node to solve the problem for the block will be rewarded, and he earns the privilege of adding/admitting the block to the blockchain.

On the other hands, PoS based method (Ethereum uses this model), uses a very different approach when validating transactions, and consequently incentivizing users whom do it. This method was built on the criticism of PoW because of its high consumption of energy and computing resources. Thus, it was proposed instead of calculating mathematical problems as in proof-of-work to generate new blocks, an owner of the next block would be chosen in a deterministic way where the chance of the person being chosen depends on the wealth (that is stake - balance in their wallet). The work of PoS based validation by users is commonly refereed as *forging or minting* as opposed to mining in proof-of-work method (however, many resources exchangeably use the term miner for both PoW and PoS methods, including this paper). In PoS there is no reward for creating a new block, so instead the minters take a payment (typically proportional to the stake held in their wallets, and in the form of a transaction fee) to certify the correctness of each transaction. Any error (deliberate or otherwise) made in certifying correctness will result in loss of stake.

III. GAMIFICATION IN BLOCKCHAIN

In this section, we identify and discuss two main motivational and human-related problems in blockchain-based decentralized systems (Section III.A and III. B). In an attempt to alleviate these problems, we propose a preliminary model for which the gamification can be a possible remedy to foster engagement and eliminate the associated risks (Section III.C). The proposed model is primarily designed for permission-less public blockchains. A public blockchain is a decentralized system that anyone in the world can read and send transactions. Public blockchain systems are usually permission-less (i.e., no access restrictions), since they aim at being fully decentralized and involve as many as possible users in the consensus process.

A. Non-Functioning User Participants

Blockchain systems are heavily reliant on their participants to actively function. Literally, a decentralized system with no users is not a network in any sense of the word. The risk of non-functioning user experience could be a threat to the success of the business that owns/runs the blockchain, either as a cryptocurrency coin or a non-cryptocurrency service.

This particular problem roots back in the underling block validation process (incentive model) that indirectly causes a massive usability issue in such systems. For many, acquiring benefits in public blockchains require a great deal of technical skills to do proof-of-stake or proof-of-work mining, making it difficult for regular consumers who lacks understanding of what it is and how to execute a transaction.

As a result of this issue, there has been unmotivated non-functioning participants in blockchain systems, creating disparity in sustainability and fairness of such systems over the long-term.

B. Unsustainable Growth of Tokens/Assets

Blockchain decentralized systems run on P2P networks of computers without the need to be controlled by any single entity, but they are required to use *tokens* to make their systems up and running. To be more specific, in the context of blockchain systems, the decentralized applications developed must meet the following criteria [32]:

- *Application must be completely open-source*: It must operate autonomously, and with no entity controlling the majority of its generating tokens.
- *Application's data and records of operation must be cryptographically stored*: It must be cryptographically stored in a decentralized blockchain.
- *Application must use a token to represent the assets*: In the forms of cryptocurrency, like Bitcoin, or any other tokens, such as smart property or secure unforgeable coupons, native to its system which is necessary for access to the application and any contribution of value from miners/minters should be rewarded with the application's tokens.
- *Application must keep generating tokens*: According to a standard cryptographic consensus algorithm (either PoS or PoW) acting as a proof of the value, nodes/users are

contributing to the application should be rewarded by receiving tokens.

In light of above requirements, the second problem identified in the blockchain systems that issue tokens is related to the *tokenization aspect* of the underling applications, which gives a negative impact on their ecosystem's sustainability. In reality, blockchain participants tend to hoard their tokens (e.g., currencies) as investment products instead of monetary media to spend for services or goods, creating a hole in the blockchain-based business model with a small level of engagement among participants. This phenomenon is mainly because these tokens (particularly virtual currencies) are not seen as ideal methods of payment due to the instability of their market' perception. As a result, this issue acts like a de-motivator for people involved to actively be engaged in moving around tokens in the system for better monetization and opportunities.

After overviewing these problems, in the next sub-section we discuss how they could be streamlined by incorporating the gamification in relevant tasks (like validation) on top of a blockchain system.

C. *Solution: Stealth Gamification*

Given the problems, we propose to build an alluring gamified layer in the architecture level of underlying decentralized applications to interface the blockchain's proof-of-stake or proof-of-work mining pool with proper game mechanics or games. This way users do not have to know explicitly they are doing mining in the traditional mind-wrecking sense by encapsulating technical details while diverting the task to a more appealing fun environment. Through this gamified mining system users/consumers can set aside funds as their stake for blockchain validation while engaged with a fun task and thereby accumulate awards and points for blocks completed. An attribute where we believe the majority of state-of-the-art works including Bitcoin fall short. In addition, this layer should include proper mechanics to gamify "spending tokens" over holing as a sort of sub-incentive mechanism to help the system becomes viable and economically flowed (addressing the second problem). By getting this solution right, companies benefit from self-sufficient marketing and engaging users while help regular people seeking accessibility to blockchain system without having to understand any of the technology or theory behind it.

Fig. 1 shows the conceptual view of the proposed model and its components in a typical blockchain system. Any participant (user) in the blockchain network may construct and broadcast a transaction (data) of which they have in control. In this case, a transaction may have a list of inputs each referring to an existing value (represented as an output of a past transaction), and a non-empty list of outputs (an output used for applications). A transaction is digitally signed in each input, which is verifiable with the public key also included in the input. The digest of the public key needs to match the digest to which the referred output is addressed. This structure is self-contained, and its validity can be verified by anyone that interact with the gamification layer's dashboard.

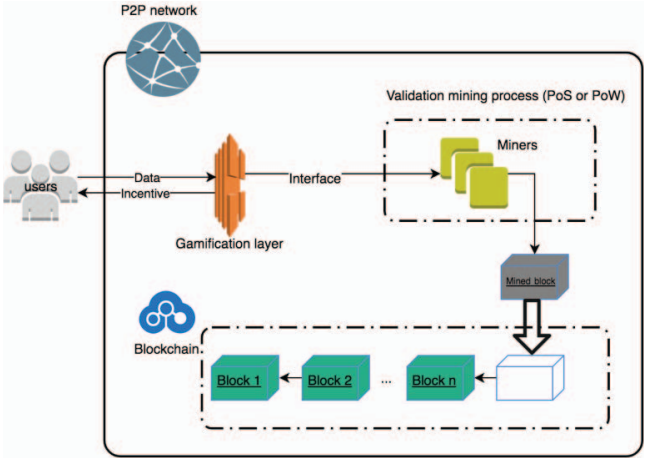

Fig. 1. Conceptual view of the proposed model.

It is also essential for those technical-savvy miners with the required skills to be treated fairly (perhaps, with a higher rates of stakes). Thus, the gamified layer should recognize this feature by embedding proper tweaks as it is infrastructurally important to the blockchain system's sustainability to incentivize professional players (i.e. miners).

From a more technical perspective, the proposed gamified addition can be built and handled by means of smart contracts using domain-specific languages, such as Solidity[1], suited for the hosting platform (of course, it might be achieved through other methodologies). In order to provide a better modularized implementation's roadmap and envisioning, Table I shows the template contracts.

TABLE I. SMART CONTRACTS FOR IMPLEMENTING THE GAMIFIED LAYER

Contract	**Purpose**	**Play as storage?**
Organizer	Main contract, working as the central point of the gamified layer	×
Players/Users	Take care of everything regarding users as well as storing user data	√
Tasks	Take care of everything regarding tasks as well as storing task data	√
Game mechanic *i*	Take care of everything regarding *i* as well as keep track of *i* data by every user (*i* represents a game mechanic such as points)	√

These smart contracts (Table I) will work as controllers as well as storages between the users and the validation process associated with the gamified environment. The first contract called *organizer* works as the central point of the gamified layer and therefore interacts with every other contract. It also provides a means to capture the required meta-data. The *users* contract handles everything regarding the user, it stores user relevant information form personal, system related, to gamified incentives. This information will be limited in the term of

[1] http://solidity.readthedocs.io/en/v0.4.24/#

visibility for other users. The *tasks* contract is in charge of managing all existing and upcoming tasks. The *game mechanics* contract handles the gamification data for each user, as an incentive result of their involvement with the mining process, i.e. game. These data (e.g., stakes) are received when completing a block and can only be spent within the system on either rewards or services from other users.

IV. DISCUSSION

In this section, we discuss several points in relation to the proposed model and its practical enforcement.

A. What would be the possible game mechanics in the blockchain space?

There are various aspects to consider and support in the gamification of a problem (a.k.a. gamification design [33]), including: understanding the problem and its best fit to gamification, knowing the target audience of the gamified environment, tailoring the context to fulfill different types of players' satisfaction, and most importantly having meaningful *game mechanics* to put into use the gamified concept.

Defining game mechanics (i.e. suitable dynamics for taking advantage to engage and motivate players in the best way) is the most challenging part of a gamified model as we seek to turn gamification into a key asset while resolving the human-related issues. This matter gets even worse due to the fresh nature of blockchain systems as opposed to traditional web applications. To help derive the suitable blockchain-specific game mechanics, we consolidated the different gamification design elements and demographics to explore blockchain ecosystems. In this regard, we reviewed the literature about game design and identified motivational elements that have been incorporated in the design of gamification in various recent studies, particularly those related to software development environment. Table II shows a suggested list of game mechanics.

TABLE II. LIST OF SUGGESTED GAME MECHANICS

Mechanics	**Effects/ benefits**
Social events	Integrating real world events performed by users with the blockchain to promote an Internet of values. For instances, make a post on Twitter/Instagram/Facebook about the blockchain company/service by the user, or invite friends should be recognized
Token spent	Progress and tracking of tokens (assets) that a user spends.
Points	Extrinsic rewards and achievement stats (stakes)
Feedback	Connecting and communal collaboration and discovery, especially for non-technical users
Consensus	The gamified layer provides the incentive mechanism. It is very important for the incentive mechanism to get all users' consensus (as one of the principals of transparent decentralized applications). This game mechanic contains the consensus-state of all users involved

To provoke feelings of motivation and engagement in users, there are five possible game mechanics at different levels of abstractions presented in Table II. Any implementation of the model requires making use of these game mechanics (as well as any upcoming additions) using a kind of vector model, where each dimension corresponds to a separate mechanic handled in a smart contract.

B. What would be the expected long-term sustainability of a game-based consensus mechanism as the interest of end users might wane in the current game?

If the blockchain developers decide to use a game instead of built-in game mechanics, it would be the hosting platform's responsibility to ensure that the substantiality of the interfacing game will be maintained well over time by collecting constant analytics to drive decisions. Maintaining the sustainability of the game is quite the case with all online games in the market. They should remain competitive and relevant to keep their users engaged.

C. How to assure the security of the gamified layer?

The gamified layer must be honest and of high security. To enforce the security of the layer, we suggest to use smart contracts as building blocks to create immutable and more secure implementation of the layer (as discussed in the preceding section). Smart contracts are secure by design, and are self-directing programs implemented through pieces of software whose autonomous execution apply the terms of the settlement and business logics in given game mechanics.

V. CONCLUSION AND FUTURE WORK

Gamification has been a trending topic for fostering user engagement and addressing human-centric concerns in the online world for the past recent years. It has not only been received well in modern mobile and web development within the industry but also in the context of academic work. This paper identified and discussed two major human-related problems in the emerging decentralized blockchain systems. For those identified problems, a preliminarily gamified model was proposed and illustrated in the context of a typical blockchain system.

We hope that our proposed work in this paper can be useful in the process of building a community-wide gamified blockchain research infrastructure to widen the horizons, especially as a start point for the discussion of what constitutes 'ideal' game mechanics in the blockchain decentralized space.

In the near future, we plan to implement a prototype of the proposed model on top of a public blockchain system and compare the prospect results with a non-gamified blockchain system. Besides and as also mentioned earlier, blockchain represents a paradigm shift from centralized computing to decentralized. In this view, another important line of future research could be the investigation how this paradigm shift changes the current game mechanics in place. Following this quest, one would like to know how a game mechanic scales (in terms of its effectiveness) when moving from centralized to decentralized systems on blockchains. A well-designed experimental study should support this investigation by giving

solid recommendations whether new blockchain-specific game mechanics need to be designed or existing ones are adequate.

REFERENCES

[1] S. Nakamoto, "BitCoin: A Peer-to-Peer Electronic Cash System," *http://bitcoin.org/bitcoin.pdf*, 2008.

[2] D. Basten, "Gamification," *IEEE Softw.*, vol. 34, no. 5, pp. 76–81, 2017.

[3] K. Seaborn and D. I. Fels, "Gamification in theory and action: A survey," *Int. J. Hum. Comput. Stud.*, vol. 74, pp. 14–31, Feb. 2015.

[4] J. Swacha, "Gamification in enterprise information systems: what, why and how," in *Federated Conference on Computer Science and Information Systems*, 2016, pp. 1229–1233.

[5] P. Herzig, M. Ameling, and A. Schill, "A Generic Platform for Enterprise Gamification," in *2012 Joint Working IEEE/IFIP Conference on Software Architecture and European Conference on Software Architecture*, 2012, pp. 219–223.

[6] G. Zichermann and C. Cunningham, *Gamification by design : implementing game mechanics in web and mobile apps*. O'Reilly Media, 2011.

[7] A. L'Heureux, K. Grolinger, W. A. Higashino, and M. A. M. Capretz, "A gamification framework for sensor data analytics," *Proc. - 2017 IEEE 2nd Int. Congr. Internet Things, ICIOT 2017*, pp. 74–81, 2017.

[8] T. G. Papaioannou, D. Kotsopoulos, C. Bardaki, and S. Lounis, "' IoT -Enabled Gamification for Energy Conservation in Public Buildings ,'" 2017.

[9] F. García, O. Pedreira, M. Piattini, A. Cerdeira-Pena, and M. Penabad, "A framework for gamification in software engineering," *J. Syst. Softw.*, vol. 132, pp. 21–40, 2017.

[10] D. Kayımbaşıoğlu, B. Oktekin, and H. Hacı, "Integration of Gamification Technology in Education," *Procedia Comput. Sci.*, vol. 102, pp. 668–676, Jan. 2016.

[11] C. H.-H. Tsay, A. Kofinas, and J. Luo, "Enhancing student learning experience with technology-mediated gamification: An empirical study," *Comput. Educ.*, vol. 121, pp. 1–17, Jun. 2018.

[12] J. C. Paiva, J. P. Leal, and R. Queirós, "Odin: A service for gamification of learning activities," in *Communications in Computer and Information Science*, 2015, vol. 563, pp. 194–204.

[13] J. C. Paiva, J. P. Leal, and R. Queirós, "Gamification of learning activities with the Odin service," *Comput. Sci. Inf. Syst.*, no. 00, 2016.

[14] J. C. Paiva, J. P. Leal, and R. A. P. de Queirós, "Design and implementation of an IDE for learning programming languages using a gamification service," in *Gamification-Based E-Learning Strategies for Computer Programming Education*, 2017, pp. 295–308.

[15] M. Z. H. Kolpondinos and M. Glinz, "Tailoring gamification to requirements elicitation: A stakeholder-centric motivation concept," *Proc. - 2017 IEEE/ACM 10th Int. Work. Coop. Hum. Asp. Softw. Eng. CHASE 2017*, pp. 9–15, 2017.

[16] F. Kifetew, D. Munante, A. Perini, A. Susi, A. Siena, and P. Busetta, "DMGame: A Gamified Collaborative Requirements Prioritisation Tool," in *2017 IEEE 25th International Requirements Engineering Conference (RE)*, 2017, pp. 468–469.

[17] R. M. Parizi, "On the gamification of human-centric traceability tasks in software testing and coding," in *2016 IEEE/ACIS 14th International Conference on Software Engineering Research, Management and Applications, SERA 2016*, 2016, pp. 193–200.

[18] R. M. Parizi, A. Kasem, and A. Abdullah, "Towards gamification in software traceability: Between test and code artifacts," in *ICSOFT-EA 2015 - 10th International Conference on Software Engineering and Applications, Proceedings; Part of 10th International Joint Conference on Software Technologies, ICSOFT 2015*, 2015.

[19] G. Fraser, "Gamification of software testing," *Proc. - 2017 IEEE/ACM 12th Int. Work. Autom. Softw. Testing, AST 2017*, pp. 2–7, 2017.

[20] E. Herranz, R. Colomo-Palacios, A. De, A. Seco, and M.-L. Sánchez-Gordón, "Towards a Gamification Framework for Software Process Improvement Initiatives: Construction and Validation," *J. Univers. Comput. Sci.*, vol. 22, no. 12, pp. 1509–1532, 2016.

[21] E. Herranz, R. Colomo-Palacios, and A. Al-Barakati, "Deploying a Gamification Framework for Software Process Improvement: Preliminary Results," Springer, Cham, 2017, pp. 231–240.

[22] D. Ašeriškis and R. Damasevicius, "Gamification of a Project Management System," in *The Seventh International Conference on Advances in Computer-Human Interactions*, 2014, pp. 200–207.

[23] J. Swacha, "Gamification in knowledge management: motivating for knowledge sharing," *Polish J. Manag. Stud.*, vol. 12, no. 2, pp. 150–160, 2015.

[24] J. Hamari, J. Koivisto, and H. Sarsa, "Does gamification work?—A literature review of empirical studies on gamification," in *he 47th Hawaii International Conference on System Sciences*, 2014, pp. 3025–3034.

[25] "HoToKeN." [Online]. Available: https://www.hotoken.io/. [Accessed: 12-Mar-2018].

[26] "Sandblock." [Online]. Available: https://sandblock.io/. [Accessed: 07-Apr-2018].

[27] "The POINT Token System: Gamification And Achievements For The Blockchain," 2017. [Online]. Available: https://medium.com/@point_token/the-point-token-system-gamification-and-achievements-for-the-blockchain-bc368978e365. [Accessed: 12-Mar-2018].

[28] "Arcade City." [Online]. Available: https://arcade.city/. [Accessed: 06-Apr-2018].

[29] "Ethereum Project." [Online]. Available: https://www.ethereum.org/. [Accessed: 09-Apr-2018].

[30] "FundFantasy - Financial fantasy trading platform - FundFantasy." [Online]. Available: https://fundfantasy.io/. [Accessed: 06-Apr-2018].

[31] P. D. Gallagher and C. Romine, "FIPS PUB 186-4 Digital Signature Standard (DSS) category: computer security subcategory: cryptography," 2013.

[32] "What is a dApp? Decentralized Application on the Blockchain." [Online]. Available: https://blockchainhub.net/decentralized-applications-dapps/. [Accessed: 09-Apr-2018].

[33] B. Morschheuser, L. Hassan, K. Werder, and J. Hamari, "How to design gamification? A method for engineering gamified software," *Inf. Softw. Technol.*, vol. 95, pp. 219–237, 2018.