Gamifying Electronic Trading Through a Minecraft Commodities Exchange

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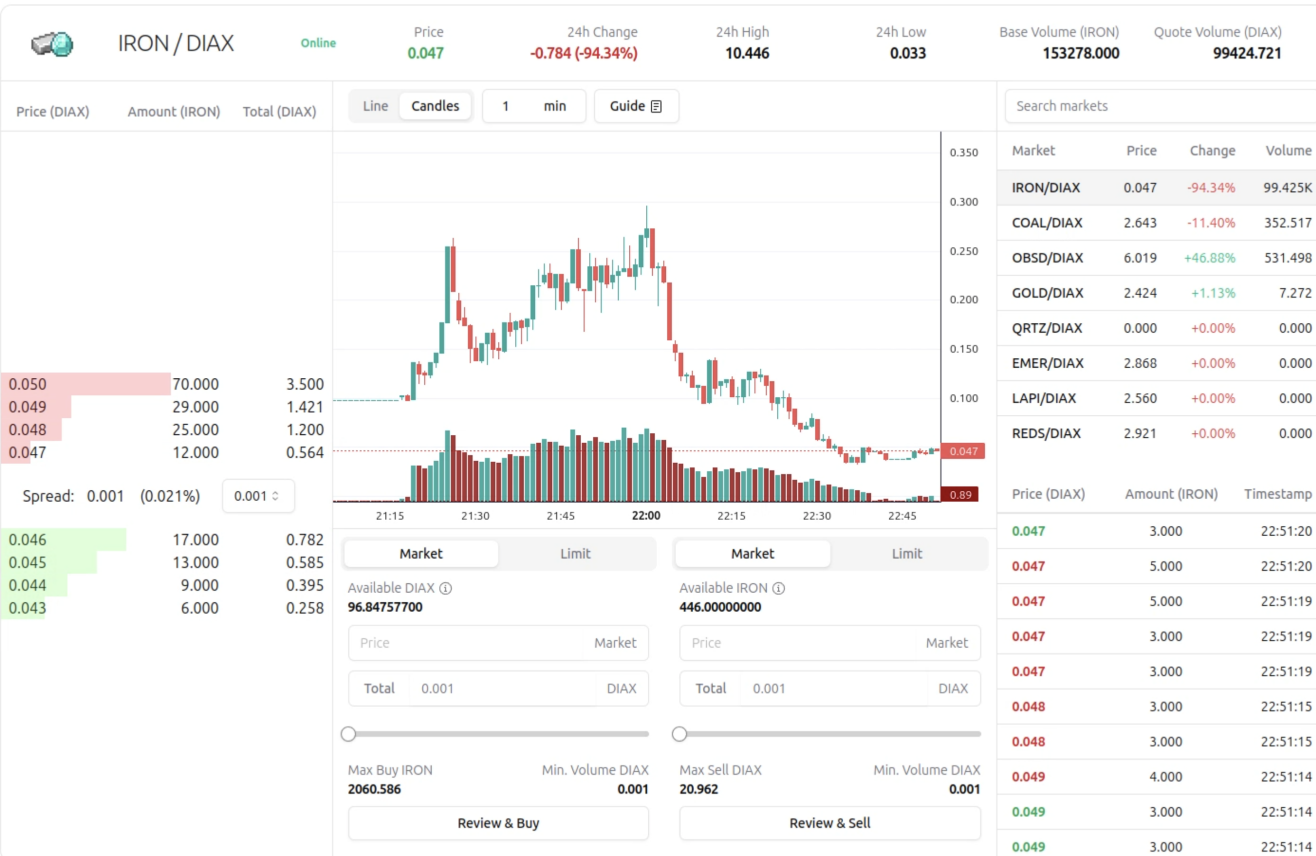

Figura 1: System Integration Developed

ABSTRACT

This paper explores the integration of a virtual commodities exchange within Minecraft, transforming in-game items into tradable digital assets. By implementing a dynamic electronic trading system, including a limit order book and market-making algorithms, the platform replicates real-world financial market operations in a familiar and interactive virtual environment. Players engage with the exchange by buying and selling assets, fostering a player-driven economy governed by supply and demand. The integration leverages Minecraft's modding capabilities through a custom plugin, facilitating seamless interaction between the game and the trading system. Beyond enhancing gameplay, this approach demonstrates significant educational potential, offering players and learners insights into market dynamics, trading strategies, and economic principles in an engaging and risk-free context. Observations of player interactions reveal authentic economic behaviors, further emphasizing the platform's value as a tool for both financial education and entertainment.

KEYWORDS

Minecraft, Electronic Exchange, Trading, Market Making, Financial Markets, Limit Order Book, Player-driven Economy, Gamification

1 INTRODUCTION

According to [1], the use of gamification to develop skills or abilities has been growing in recent years, where gamification means the use of games in non-game environments. Also, this learning technique brings some benefits to the educational system, such as learning with opportunities to start, make mistakes, stop, and try again every time and place.

To apply gamification in educational systems, five steps should be followed:

- Mechanics - rewards, avoidance elements, status indicators, tasks, and rules [2];
- Dynamics - experiences in the process [3];
- Esthetics - emotions experienced by the person in the process [3];
- Story - artificial situation with characters, objectives, and challenges [4];
- Technology - concrete materials, information, and communication technologies employed in the gamification process [2];

As stated in [5], each educational game has two main aims: Firstly, developing some abilities or competencies; Secondly, it must be fun. Some examples are presented in Table 1.

Game	Skills or Abilities
Pac-Man	Strategy
Fair-Play	Ethical Sports
Tetris	Motor Coordination, Imagination, and Reasoning
Boarding Games	Communication, Logical Reasoning, Attention, Concentration and Social Interaction

Table 1: Examples of Gamification [5]

Figure 2 shows the distribution of new teaching techniques based on gamification; its success can be observed through diversification and adherence to the latest teaching model. Also, it is possible to observe its use in big fields such as medicine, engineering, languages, and programming. In Languages, the famous Duolingo is used to learn different languages worldwide.

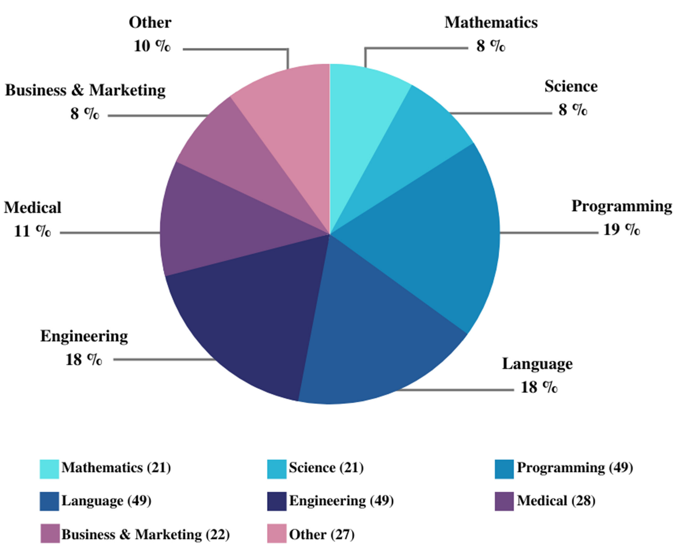

Figure 2: Fields of Application of Gamification in Education [1].

Minecraft, launched in 2011 by Mojang Studios, exemplifies a game ideally suited for gamification. This sandbox video game immerses players in a pixelated, procedurally generated three-dimensional world where they explore, build, and interact. The game revolves around survival and resource gathering, featuring a crafting system that allows the conversion of basic resources into complex items, tools, and structures. Moreover, Minecraft offers both solo and multiplayer experiences, allowing players to collaborate or compete within shared virtual worlds [6–8].

Minecraft's modding capabilities enable the development of community-driven plugins and mods that create diverse server experiences, blending virtual governance with player interaction [9, 10]. It is widely used in educational settings to gamify learning, enhancing student engagement through interactive and immersive play [11, 12].

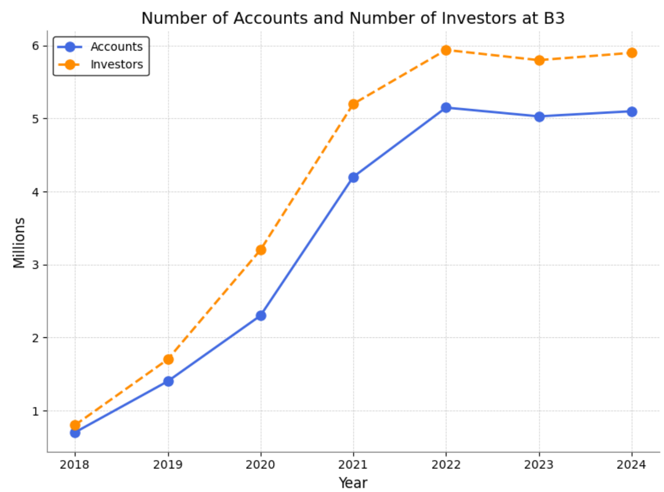

Figure 3: Number of Accounts and Invertors in the B3 (Brasil Bolsa Balção)

Moreover, the growing public interest in financial markets highlights the need for engaging educational tools. As shown in Figure 3 and supported by studies [13–17], the number of investors soared from 0.7 million to 5.1 million between 2018 and 2024, an increase of 628%. Additionally, data from the Receita Federal do Brasil indicates that between 2019 and 2023, the number of individual crypto investors grew from 186,726 to 3,217,633, an increase of 1623%, highlighting a similar trend among cryptocurrency enthusiasts [18]. This trend indicates a rising engagement with financial markets among this demographic. Concurrently, virtual economies in digital games have become crucial for simulating economic dynamics, enhancing gameplay and serving as practical tools for education in economic principles [19].

For instance, in EVE Online, a space-themed MMORPG, players manage a complex, player-driven economy, handling everything from resource trading to insuring spacecraft, mirroring real-world macroeconomic principles such as wealth inequality [20, 21]. Similarly, RuneScape's *Grand Exchange* reflects market dynamics, with prices dictated by supply and demand, offering a practical way for players to understand economic concepts like price elasticity [22, 23].

World of Warcraft (WoW) also simulates real economies, with in-game events affecting currency supply and inflation, while the exchange of *WoW tokens* ties its virtual economy directly to the real world [24]. However, Minecraft's *vanilla* version lacks native tools for player transactions. By integrating an electronic commodities exchange, we can establish a player-driven in-game economy that enriches player interaction and gameplay mechanics and opens up educational opportunities in finance.

Observing the growing demand for teaching in different areas using gamification, this paper introduces the integration of a virtual commodities exchange into Minecraft, enabling in-game items to be traded as financial instruments. Through the implementation of an electronic trading platform featuring a limit order book and market-making algorithms, the system simulates real market principles, fostering a player-driven economy based on supply and demand. Beyond enhancing gameplay, the primary goal of this approach is to provide an interactive educational tool to teach financial concepts such as financial engineering, trading, risk management, and algorithmic trading.

The remainder of this paper is organized as follows: Section 2 discusses the fundamentals of exchanges and financial markets, while Section 3 describes the technological architecture used in the project. Section 4 elaborates on the trading system, including the market-making algorithms. Section 5 examines the results and behavioral implications, and Section 6 concludes with reflections on the educational potential of the system and suggestions for future work.

2 EXCHANGES

Stock exchanges epitomize the evolution of economic and financial ingenuity, serving as vital venues for trading diverse financial instruments like stocks, bonds, commodities, currencies, derivatives, and crypto-assets. These exchanges act as crucial barometers of global economic health [25–27].

The first formal stock exchange was the Antwerp Exchange, established in 1531. Distinguished by its organized trading of diverse financial instruments, this exchange boosted the economy and significantly influenced European cultural and economic modernization [25].

The emergence of formal exchanges such as the London Stock Exchange in 1773, followed by the Philadelphia and New York exchanges, marked the expansion of organized trading. The launch of NASDAQ in 1971 introduced electronic trading, eliminating the need for physical trading spaces and heralding an era of enhanced efficiency and accessibility [28].

Modern exchanges, such as the IEX founded in 2012, exemplify the constant evolution of trading platforms by emphasizing fairness and transparency. By implementing measures to counteract predatory trading strategies, these exchanges actively protect the interests of long-term investors, thereby contributing to the progressive modernization of financial markets [28, 29].

Furthermore, the advent of crypto-asset trading platforms has expanded the financial sector by introducing derivatives of cryptocurrencies and the tokenization of traditional commodities like gold and oil. This tokenization provides greater liquidity and democratizes access to previously inaccessible markets by converting physical assets into tradable digital tokens [30, 31].

Electronic exchanges, whether stock exchanges, currency exchanges, bond exchanges, or cryptocurrency exchanges, are advanced trading infrastructures that operate exclusively through computerized systems. These modern platforms are designed to provide high efficiency, speed, and transparency in financial transactions, offering a secure and reliable environment for buying and selling financial assets. This technological evolution has significantly transformed financial markets, making them more accessible and operational on a global scale [28, 32].

Given the significant role that exchanges play in the global economy, integrating similar mechanisms within a virtual environment like Minecraft can serve as an engaging gameplay feature and a powerful educational tool. By simulating real-world trading and market dynamics within the game, players can gain a deeper understanding of economic principles and financial markets in an interactive and accessible way.

2.1 Instruments

In finance, tradable instruments are denoted by *tickers*, unique symbols that facilitate their identification in electronic trading systems [32]. For instance:

- **AAPL**: Apple Inc.
- **BTC**: Bitcoin.
- **AUX**: Gold.
- **PETR4**: Petrobras (Brazilian stock exchange).

In the Minecraft-based exchange developed for this project, items for trading have 4-letter tickers, such as **DIAX** for diamonds, **IRON** for iron ingots, **GOLD** for gold nuggets, and **COAL** for coal.

2.2 Markets

A "market" in the financial context is characterized by combining two distinct financial instruments: a base instrument and a quote instrument. This setup establishes the exchange relationship or price dynamics between two assets, allowing participants to assess the value of one asset in terms of another. [32, 33]. Some examples of real markets include:

- **BTC/USD**: Bitcoin versus US Dollar.
- **PETR4/BRL**: Petrobras shares versus Brazilian Real.

Similarly, in our Minecraft exchange, items are paired with diamonds as the quoted instrument, such as **COAL/DIAX**. This mimics fundamental financial markets where the value of goods is determined relative to a stable asset, helping players understand and engage in trading.

2.3 Order

An order is a directive sent by a user to an electronic exchange to buy or sell a financial instrument, detailing the desired quantity, price, and transaction direction [32]. Key attributes define each order:

- **Price**: The desired transaction price.
- **Quantity**: Number of units to transact.
- **Side**: Buy (**BUY**) or sell (**SELL**).

- **Timestamp**: Time of order placement.
- **Order ID**: Unique identifier for tracking.
- **State**: Execution progress (*fulfilled*, *remaining*).
- **Status**: Current order status (*open*, *cancelled* or *completed*).
- **Type**: *limit* (**Limit Order**) or *market* (**Market Order**).

Additionally, orders on an electronic exchange are categorized into two primary types, each serving distinct strategic purposes in trading:

- **Market Orders**: These execute immediately at the best market price. Market orders do not specify a price and are designed for rapid execution, absorbing the available liquidity in the order book.
- **Limit Orders**: These require setting a specific price and will execute only when the market price matches or is more favorable than the specified price. Limit orders contribute to market liquidity as they are placed in the order book and are awaiting a matching order from another trader.

Both types of orders play crucial roles in the dynamics of market liquidity. Market Orders prioritize speed, ensuring quick trades without concern for price fluctuations. In contrast, Limit Orders focus on price certainty, providing traders control over their trade execution prices [32].

2.4 Order Book

Each market has its order book (*limit order book* or *LOB*) that organizes buy and sell orders to facilitate transactions [34]. As illustrated in Figure 4, orders are structured in a binary tree by price, and time—buy orders (bids) are sorted in descending price order. In contrast, sell orders (asks) are sorted in ascending order.

In the example, the order book for the **BLAZ/DIAX** market (blaze rods quoted in diamonds) shows bids at the bottom and asks at the top, demonstrating how the LOB visually represents the supply and demand for a particular asset. The horizontal colored fill visually represents the available volume at the price level.

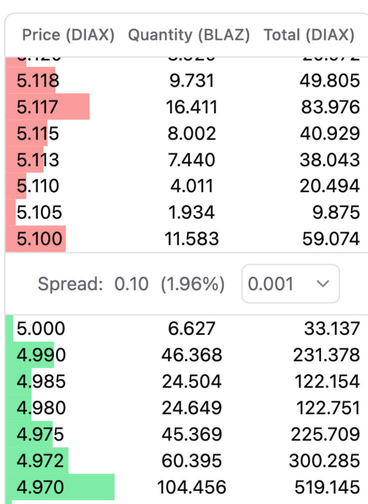

Figure 4: An Limit Order Book of the BLAZ/DIAX market (blaze rods quoted in diamonds) as shown in the platform.

2.5 Order Matching Engine

The Order Matching Engine is responsible for the actual execution of trades. It continuously compares orders in the limit order book (LOB). The engine initiates a match when the highest buy order (with the highest bid) has a price equal to or greater than the lowest sell order (with the lowest ask). Orders are prioritized first by price and then by time, ensuring that the earliest orders get precedence at each price level.

When a match occurs, the engine executes a transaction where the quantities and prices from the matched buy and sell orders fulfill each other. If the amounts of the buy and sell orders are perfectly balanced, both orders are completed. If they are not, one order may be fully fulfilled while the other remains partially open, seeking further matches. This process is recursive, continuing until no compatible orders are left or the order book cannot balance further due to price disparities between remaining buy and sell orders.

In the context of order execution, each order can assume the role of either a **Maker** or a **Taker**, influencing how liquidity is added or removed from the order book:

- **Maker Orders**: These orders add liquidity to the order book. When a limit order is placed at a price that does not immediately match an existing order, it remains in the order book, thereby "making" liquidity available for future trades. Makers provide depth to the market, enhancing its stability and reducing volatility.
- **Taker Orders**: These orders remove liquidity from the order book. A market order always falls into this category as it consumes the available liquidity by executing immediately against the best available prices. Additionally, a limit order can act as a taker if placed at a price that matches or crosses existing orders, resulting in immediate execution.

2.6 Wallets

Upon a successful transaction by the Order Matching Engine, wallet balances are updated to reflect the asset redistribution between participants. Specifically, when a user sells an asset (the base instrument), their wallet receives credits in the quoted instrument, reflecting the transaction price.

Conversely, the buyer's wallet is debited the amount in the quoted instrument and credited with the acquired base instrument. An example of what the wallets overview looks like can be seen in Figure 5.

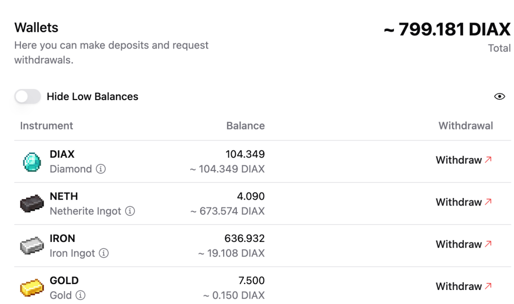

Figure 5: Wallets overview in the exchange.

3 TECHNOLOGY ARCHITECTURE SUMMARY

The modular exchange system is based on a back-end core in C++, a Svelte front-end for user interaction, and a Python middleware that exposes an API and facilitates communication between components. Additionally, a Minecraft plugin integrates the game with the virtual commodity exchange, enabling deposits and withdrawals from and to the system.

3.1 Core (C++)

The core backend is built using Modern C++23, engineered for high concurrency through multi-threading, and optimized for minimal latency. This system is the central hub for handling transactions, order management, and maintaining the limit order book, among other financial operations. It exposes a WebSocket API for real-time communication while incorporating multiple mutexes to safeguard data integrity and security. Special attention is given to reducing the lock time across all system components to enhance performance and efficiency.

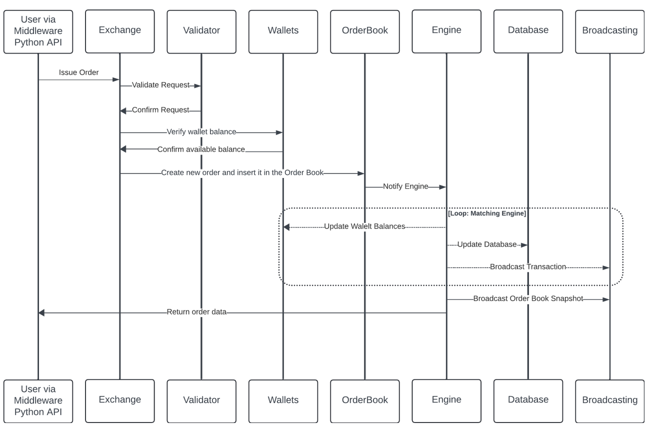

Figure 6: Flow Processes System

The diagram in Figure 6 provided is a sequence diagram to illustrate the flow of processes in a system. The user interacts with the system via a Python-based middleware API to initiate actions like issuing an order. For example, the user sends a request (e.g., to buy or sell an asset) to the exchange via the middleware Python API. The exchange forwards the user's request to the validator to check its integrity (e.g., proper format, valid fields). If the request is valid, the validator returns it to the exchange. The exchange checks the user's wallet to ensure sufficient balance for the requested operation. The wallet component confirms whether the user has enough balance. A new order is created and added to the order book. The order book notifies the matching engine about the new order.

3.2 Middleware (Python)

The middleware (Fig. 7)leverages Socketify.py asynchronous library capabilities to act as a communication bridge between the front-end and the exchange core, managing WebSocket connections and asynchronous HTTP requests. It also implements caching techniques to speed up data retrieval and reduce the load on the central core system. It handles authentication and authorization using the open-source Logto Identity and Access Management (IAM) platform.

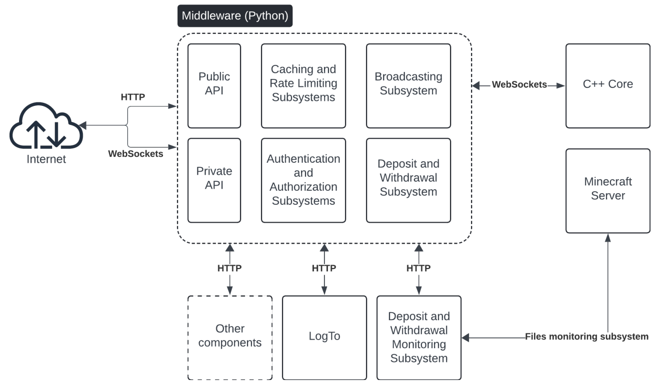

Figure 7: Middleware

3.3 Front-End (Javascript)

The front end is developed using the Svelte framework, providing a reactive interface that includes market visualizations, order management, and a dashboard for transactions and wallet management. The design focuses on usability and quick responsiveness to user interactions, leveraging a minimal user interface. It establishes a WebSocket connection with the backend and subscribes to the broadcast of new transactions and order book snapshots displayed to the user in real time.

3.4 Minecraft Integration

To seamlessly transfer items between the Minecraft world and the exchange platform, a server plugin introduces two special chests—the deposit chest and the withdrawal chest—that allow players to move items to and from their exchange accounts. By using familiar game mechanics like interacting with chests, this integration enables seamless item transfers between the virtual game world and the exchange.

Players place items from their inventory into the deposit chest and confirm the action for deposits. The items disappear from the game world and are credited to their exchange account. The plugin signals the exchange with details such as items, quantities, player ID, and timestamp, allowing the platform to update the player's wallet accordingly.

Withdrawals work in reverse. Players select items and quantities to withdraw from their exchange account via the platform. The system deducts these items from their wallet and signals the plugin with the withdrawal details. The plugin then places the items into the withdrawal chest in the game. Although accessible to all, the withdrawal chest is segregated so that each player can only see and retrieve their items.

This system ensures no item duplication and maintains the integrity of the game world and the exchange platform (see Figure 8).

4 TRADING

The items available for trading on the platform include, along with their *tickers*, diamond (**DIAX**); netherite bar (**NETH**); iron bar

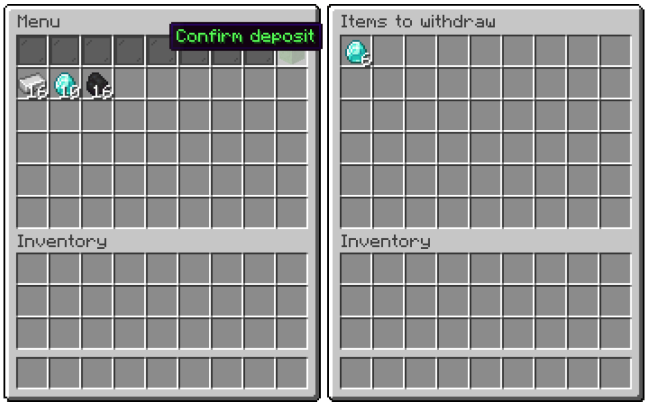

Figure 8: Left: Player selecting and moving items from their inventory to the deposit chest before confirming the deposit. Right: Player checking items in the withdrawal chest, about to move them to their inventory.

(**IRON**); gold bar (**GOLD**); netherite scraps (**NSCR**); coal (**COAL**); wood (**WOOD**); bone (**BONE**); lapis lazuli (**LAPI**); wool (**WOOL**); dirt (**DIRT**); gravel (**GRAV**); flint (**FLNT**); blaze rod (**BLAZ**); ender pearl (**ENDP**); TNT (**TNTX**); sand (**SAND**); arrows (**ARRW**); gunpowder (**GUNP**); obsidian (**OBSD**); apple (**AAPL**) and copper bar (**COPR**), all of these items have markets paired with diamonds (**DIAX**).

Users interact with the platform by buying and selling tickets and issuing market or limit orders. Market orders are executed immediately at the best available price, requiring users only to specify the quantity. On the other hand, limit orders allow users to set the desired price and quantity, offering control over the execution price, as depicted in Figure 9, which illustrates a trade ticket configured to place a limit buy order.

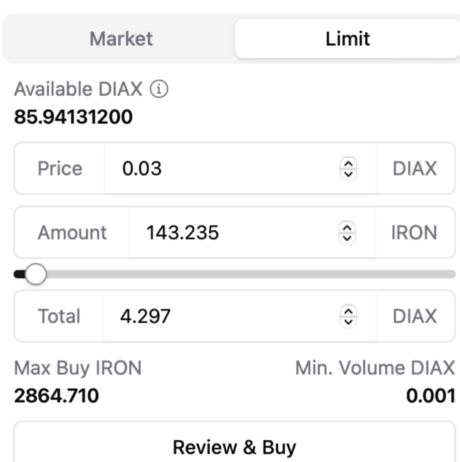

Figure 9: Trade ticket configured to place a limit buy order, specifying the price and quantity of the asset.

A slider allows users to adjust the buying or selling quantity from 0% to 100% based on the available volume or balance, facilitating the specification of quantities without manual input. Before execution, market and limit orders are summarized on a confirmation screen, ensuring that users verify all relevant information before finalizing the transaction. Figure 10 shows the Order Confirmation screen before placing a market buy order.

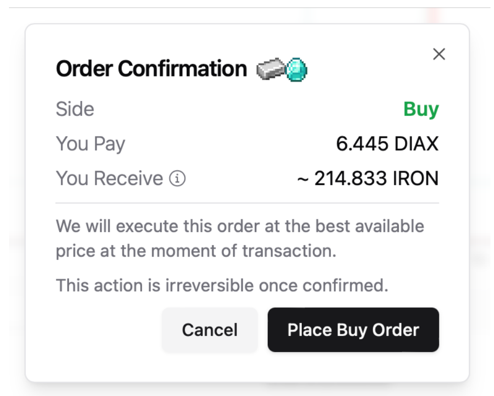

Figure 10: Order Confirmation screen before placing a market buy order. It details that the user is paying 6.445 DIAX and will receive approximately 214.833 IRON.

4.1 Market Making Algorithm

Market making is a financial strategy where an agent — the market maker — maintains active buy and sell orders in the order book to ensure constant liquidity and reduce market volatility. These agents facilitate the trading process by ensuring that prices for buying and selling assets are always available [35].

A simplified market-making algorithm has been implemented on the platform to provide liquidity, which is crucial during the initial operation phase when user activity is still developing. The algorithm employs a passive approach by arranging buy and sell orders at various price levels, which continuously adjust in response to market transactions.

The market-making algorithm volumetrically distributes orders in the order book based on an exponential function of volume weights, denoted by $w_i = \exp(i)$, where i is the index of the price level, and w_i is the weight assigned to the volume at that price level. This method results in smaller volumes for price levels closer to the current price and larger volumes for those further away, reflecting a distribution that intensifies as it moves away from the market price. Figure 11 illustrates how orders are distributed in the order book according to this algorithm.

Additionally, to add a layer of randomness, Gaussian noise, $v_i = w_i + \epsilon_i$, is incorporated, where ϵ_i follows a normal distribution

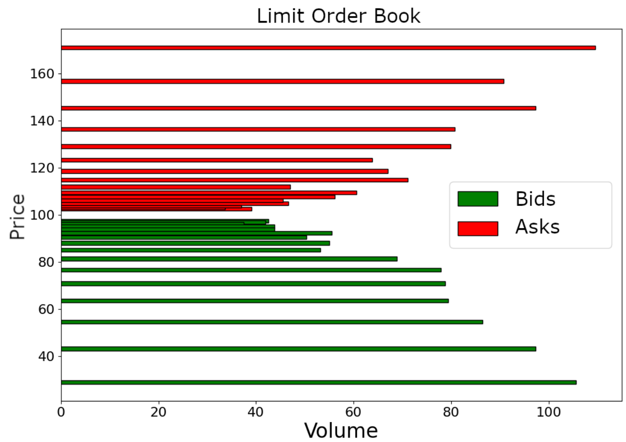

Figure 11: Example of a Limit Order Book with a market price of 100.0, where the volume of orders increases as they move further from the market price, reflecting the algorithm's volumetric distribution strategy.

$\mathcal{N}(0, \sigma)$. Here, ϵ_i represents the noise term added to the volumetric weight w_i, and σ is the standard deviation of this noise, defining the extent of volumetric variations and adding visual variability to the order book.

Operationally, the algorithm starts by canceling all existing orders for a specific asset and setting up new buy and sell orders. These are defined based on parameters such as the number of price levels, the base volume, the percentage spread (s), and an exponential factor (γ), which regulates the increase in price increments between levels, calculated by $\Delta p_i = p \cdot s \cdot \gamma^i$. This procedure creates a symmetrical distribution of orders that starts from the price closest to the market and expands to higher and lower prices alternately for sales and purchases.

5 RESULTS

Establishing a commodity exchange within the Minecraft universe provided a live laboratory for observing economic dynamics despite its experimental nature and short lifespan. The exchange functioned as an active market, offering a stage for analyzing financial interactions.

The market-making algorithm commenced operations with base prices that did not adequately reflect the abundance and ease of obtaining certain items, creating profitable opportunities that market participants quickly exploited. This section highlights two particular instances of economic exploitation resulting from this initial stage.

5.1 Case 1: Ender Pearls

The first notable observation involved mob traps in the End dimension. These traps were designed as large pits intended to capture endermans. The trap structure started with a flat surface, interrupted by a significant hole where the endermans would fall.

After falling, the endermans were confined in a narrow space at the bottom of the pit, with an opening of only two blocks in height, which was insufficient for them to escape due to their taller stature. This allowed the player to eliminate them without risk of retaliation. The ender pearls collected were then sold in the **ENDP/DIAX** market in exchange for diamonds, capitalizing on the initially inflated prices.

5.2 Case 2: Flint

Similarly, Flint, quoted in the **FLNT/DIAX** market, became the target of similar exploitation. Players massively collected gravel to extract flint and sell it for diamonds, benefiting from the highly profitable and poorly adjusted initial market prices. These observations highlight how players quickly identified and exploited vulnerabilities in a poorly adjusted pricing system, revealing adaptive economic behaviors even in a virtual environment.

6 CONCLUSION

This project has successfully brought a virtual commodities exchange into the world of Minecraft, turning in-game items into tradable assets and creating a vibrant, interactive economy. With features like a limited order book, market-making algorithms, and an economy driven by supply and demand, the platform allowed players to experience the dynamics of real financial markets engagingly. It was fascinating to see how players naturally adapted to the system, even finding ways to exploit inefficiencies—proof of how realistic the simulation was.

While experimental in nature, the platform shows incredible promise as an educational tool. It makes complex financial concepts—like trading strategies, risk management, and price dynamics—more accessible and fun to learn. By gamifying these ideas opens the door to a more hands-on, intuitive way of understanding finance and economics.

Of course, there's room to grow. Adding advanced tools like futures and options, creating more challenging economic scenarios, and measuring their impact on learning outcomes would improve the platform. Integrating it into educational settings and running controlled studies could also help solidify its role as a teaching tool.

Ultimately, this project shows the power of combining gaming and education. It's a creative way to make learning finance easier and genuinely enjoyable. With some refinements, this approach could inspire a new generation to dive into the complexities of economics while having a great time in a virtual world.

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