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Gamification applications in a warehouse order picking system using Octalysis method

by

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Abstract

In today's world, gaming industry has been conquering other industries as a powerful tool to support and increase user engagement. By applying one of the more structured gamification methodologies called Octalysis in warehouse order picking process, it is possible to have more loyal order pickers with prolonged employment life and promote transferring knowledge among team members. Octalysis converts all conventional motivational factors into 8 core drives which based on them, games can both be build and assessed and compared. After gathering and preparing some gaming scenarios from different sources such as other scientific papers and thesis, consulting with business experts and research team experience, and evaluating them with Octalysis and eliminating non-desirable scenarios, it is possible to build a prototype game for order pickers based on the most fit scenario and later measure the progress with EEG data and other Neuroscience analytics for human mind criteria such as cognitive load, stress. After reviewing EEG results, the prototype will be reconsidered and fine-tuned using EEG findings and this cycle continues to reach an acceptable and presentable game. To achieve this interdisciplinary goal, more in-depth literature review from Logistics, Psychology and IT domains are required which will be done during the first year after the proposal, and the game will be finalized within 6 months after reviews and final 6 months is dedicated to dissertation compilation.

Keywords: Warehouse order management, Gamification, Octalysis method.

1. Introduction

1.1. Issues with order pickers

One of the current warehouse industry issues is the high HR (Human Resources) turnover (U.S. Bureau of Labor, 2023), which inflicts great costs and risks to any warehouse environment. This problem among order pickers is more critical as it imposes greater risks on warehouse operations. On the other hand, the order picking process consists of routine tasks, which are more or less the same in all warehouses, which makes these crews easier to tackle and resolve. Adding more details illuminates research opportunities in this domain.

1.2. Warehouse operations

Warehouse operations can be divided into three distinct categories:

1. Inbound: processes related to material entering warehouse, such as unloading, controlling, put-away
2. Storage: processes involving optimizing costs and risks to take good care of stocked goods in the warehouse, such as maintenance of warehouse and its facilities, training staff, stock keeping, enforcing required ambient conditions such as temperature, humidity and light, and security measures
3. Outbound: processes which are designed for meaningful agility and precision for products journey to their next destination such as order picking, packing, loading, and shipping

1.3. Order picking:

The order picking process is one of the most costly and complex ones in warehouses with so many details to consider by pickers. Picking process is a set of procedures designed to pick requested material, usually listed in a picking list with two main criteria groups for each item:

- Specifications such as product description, barcodes, batch numbers, expiration date, arrival date.
- Quantity manifested in units such as kg, meter, liter, packages

If worker needs to fulfill a picking list, he needs to know where each item lies in the warehouse and how to find them quickly in many other similar products with similar specs and after translating quantity unit in picking list (e.g. 10 kg of rice) to warehouse units (two bags of 5kg rice), pick exactly what is requested and bring back all material in the list to the packing area. If there is a discrepancy, such as an expired batch of products or shortage of another, there are certain procedures which need to be followed by the picker, based on the priority and severity of said discrepancy in each case. There are numerous other issues which have their own procedures as well, such as damage to products, risky product placement, consuming consumables, damage to warehouse building, burning smells, water leakage and so on and so forth.

1.4. Third Industrial Revolution

During “Third Industrial Revolution” (digital age) lots of these processes were taken care of with a WMS (Warehouse management system). Not only a WMS could provide pickers with the address of each item, but it could give an optimized route, voice direction in their headset, optimized order of items. But still there were lots of aspects which were more complex and could not be addressed by WMS alone. For example, what if the picker takes the wrong product or incorrect quantity, or even misses a product and does not take anything at all? What if he is not aware of the correct way to report discrepancies, or simply does not care to report anything at all? It is arguable that some controlling systems could be designed and put in place for some issues, but not for all issues, and even if it was feasible, it still increased cost and time, as well as complexities.

1.5. Fourth Industrial Revolution

Fourth Industrial Revolution (Industry 4.0, some call it imagination age) have some distinction than the previous age:

1. Data are much more easily stored and accessed for all units, people, devices, organizations etc.
2. All sources of data are interconnected and can be exchanged much faster almost free in relation to their added value
3. Lots of tasks (or better say decisions) are automated, and humans do not need to be involved for every little detail
4. Tasks or decisions which are not automated, can still be supported by systems which rely on historical data, similar data, predicted data by usage of methods such as machine learning with a faster and safer problem-solving abilities

Since picking requires high levels of precision and agility with prerequisites of variety of skills, and actions that are involved in performing the task, it still cannot be replaced totally by automated systems. Despite the availability of some new generation order picking support systems (OPSS), such as pick-by-vision (Reif, 2009) or others that use augmented reality with warehouse workers, majority of these systems cannot be economically justified yet, if ever. This puts order picking a highly labor-intensive (dependent on human workers).

1.6. Picker's general working Conditions

Nowadays a picker's job description is mainly consisted of getting a list of products with quantities in a paper or in a handheld device, separating mentioned quantity and put it on warehouse material handling device (jack pallet or order picker machine) and bring it back, over and over again until your daily tasks are finished, during which due to insulations used all over the building walls, hearing any sounds other than their own walking noises is rare and since warehouses are vast places with few staff present, human contact is minimal and limited to a handful of people every day. For security reasons, a picker does not know where the picked products are sent to, and in more severe cases (such as beauty and hygienic products with high value and liquidity) they don't even know what they are picking, some boxes with barcode or QR code, so there is no sense of immediate achievement or productivity for pickers as much as there is for other jobs. Due to the high ratio between pickers and warehouse administrative staff, there are not foreseeable promotions and due to a completely different set of pre-requisites, job transformation does not seem possible either.

Improvements to job satisfaction and working conditions have a glass ceiling: warehouse design. Generally, warehouse spaces are optimized to contain goods and products, not to contain humans. If a picker works in a cold-storage, he needs to wear a heavy jacket, even in mid-summer. Due to rising energy costs and safety guidelines, lights are usually set to industry minimum of 150 LUX and there are other regulatory codes such as mobile usage prohibition or safety shoes etc. And we should not forget to mention the location of warehouses: remote places near junctions of two main routes with no access train stations or bus stops, let alone supermarkets or other facilities. These gaps can be compensated with some monetary incentives to some extent, but eventually fatigue is inevitable.

Job security is another factor that needs to be considered. One of main issues in each warehouse is balancing its resources and as HR being main resource of picking, it is dependent on forecasted outbound volume of the warehouse, which is output of multiple other factors itself. There are some strategies that keep outbound fluctuations to a minimum, but still there is not much improvement that can be done in this domain.

1.7. Picker's career cycle span

The combination of monotonous repetitive tasks with harsh working conditions which were mentioned earlier makes order picking one of the most troublesome jobs in industry today with high turnover. According to United States Bureau of Labor, between 2013 and 2023 there has been 46% of separations annually in "Transportation, warehousing, and utilities" while total industry separations average stays at 15% (U.S. Bureau of Labor, 2023). Some

reports show that HR turn in warehouses in is not even incentive-sensitive (Min, 2007) or and have no sensible effects on learning (Sgarbossa, 2022). On the other hand, a well-trained picker has an extensive knowledge of warehouse operations, stocked products, cautionary and risky points, which is essential for reducing the time required to complete the task with high accuracy and safety. Since most of picker's trainings are OTJ (On the job), it can be assumed that extending picker's employment period enhances warehouse agility and decreases the number of employees, thereby minimizing complexity and risk by some degree.

1.8. Potential research opportunities:

These are some of the questions that will be addressed are as follows:

- How should the order picking process be approached to decrease HR turnover for warehouse pickers and subsequently increase productivity and efficiency in warehouses? Is it possible to use a game environment to achieve these goals?
- What method of gamification should be implemented and what filters and elements should be used? How to distinguish between different scenarios and what measures and criteria should be applied to assess each scenario?

2. Literature Review

2.1. Motivation factors

In a literature review on motivation (Sekhar, 2013), "training, monetary incentives, job transfer, job satisfaction, promotion, working conditions, achievement, appreciation, recognition, job security, social opportunities" considered to be of general motivators. As was mentioned, financial incentives do not have long-term effects in this domain. Job transfers, promotions and social opportunities are not possible. Most of the training is OTJ. And job satisfaction, working conditions and job security have their own glass ceilings and cannot be improved significantly. There are other methods which can motivate pickers. Remaining elements would be achievement, appreciation, and recognition which although seem hard to be considered in a timely manner by administration, it is possible to be improved with application of some tools and methods.

2.2. Motivational tools in order picking:

Some tools which are currently being used in warehouses, as combined in (Bahr, 2022) from several other papers, are:

- Points: works as a currency in warehouse environment which is given to staff for accomplishments and achievements
- Achievements: set of goals to be reached by staff which works as a guideline for improvement, for example: "finish 1000 order picking"

- Levels: shows total proficiency of each staff which may be used for achievements definitions
- Missions: set of tasks that should be done with some criteria to get a reward or points, for example “finish three order picking in less than 2 hours”
- Contests: same as missions, but with some competitions between participants, for example “finish three order picking faster than three other staff”
- Leader board: periodically documentation of staff ranking, for example list of 10 staff with the most quantity of finished order picking this week.
- Notifications: to push staff on doing some specific tasks like “new order lists available on dry food section” or “for the next one hour, every finished order picking is awarded with 20% bonus”
- Timers: shows time remaining to a milestone, such as finishing a task or start of a new opportunity
- Performance charts/graphs: to visualize performance toward KPIs (key performance indicator) for an easier understanding of the general conditions
- Multimedial Feedback: brief feedback to each person by a sign or number to show individual performance toward expectations

With mentioned tools above, not only it is possible to improve remaining elements from previous section (achievement, appreciation, and recognition) significantly, but also some other aspects such as job satisfaction and socializing aspects can be improved, as these systems connect staff in some ways that were not possible before, such as competitions in contests or unity in performance charts or comparison in leader boards.

2.3. Gamification with Octalysis

Applying gamification method which involves numerous tools such as badges application and badge definitions, points, achievements, levels, missions, contests, leaderboards reduce monotony and brings motivation into play. According to (Bateman, 2018) To successfully implement these elements, effectiveness of each combination of these elements, which we may call “scenario” going forward, should be measured, and compared to the whole group of Scenarios.

Figure 1, Octalysis Framework

Octalysis framework (Chou, 2023) is used to assess and score each scenario which makes scenarios comparable. Some of key points of this framework is as follows:

- It has 8 core drives (CD), which are shaped like an octagon.
- Left ones are extrinsic (need something from outside to motivate player, such as a half full progress bar for an OCD player) and right ones are intrinsic (does not anything from outside, like creativity in a painting)
- Upper ones are positive (rewarding) while lower ones are negative (penalizing)

In (Sochor, 2021) some of these elements was categorized as follows:

Table 1. Conversion of conventional motivation factor into related Octalysis Core Drives

Game Element Groups with Description	Example	Core Drives
Points are fundamental elements in many games, which reward players for the successful completion of tasks.	Experience points	CD2, CD3, CD4
Levels and Scores display the progress or advancement a user has already achieved in a game.	Levelling system	CD4, CD6
Badges and achievements are digital artefacts, visual possessions or trophies granted for accomplishments.	Trophy shelves	CD4, CDS

Counters and timers visually show the passage of time towards a specific event.	Countdown timers	CD3, CD6, CD8
Quests are tasks, which often relate to meaningful stories as part of the overall telling of a story.	Daily quests	CD4, CDS, CD8
Performance graphs / progress bars display user or team performance graphically and progress on a bar.	Performance graphs	CD2, CD3, CD8
(Team) leaderboards are lists of users, which are ordered by one or more variable.	Anonym leaderboard	CD2, CD7
Crowning honours a user for exceptional behaviour or performance during a pre-defined time period.	Employee of the week	CD1, CD5
Multimedial feedback shows results by meths of direct visual, acoustic or textual feedback.	Traffic light smileys	CD3, CD5, CD8
Suggestions / advice aim to help users, who do not know how to proceed or need selection choices.	Pick-by-light system	CD2, CD3
Metaphorical or fictional representation is the art of illustrating non-game content with metaphors or fiction.	Fictional scenario	CD1, CD7
Avatars are visual representations of users in form of a chosen character, which clearly identity them.	Customizable avatars	CD3, CD4
Narratives are the composition of stories with higher meaning which form the telling of an overall story.	Open-world narrative	CD1, CD7

Some of downfalls of gamification in workplace is as can be seen in work of (Bateman, 2018), is that it could be a mask to make an already harsh environment even more bitter with enforcing employees to competition: “To invite play into the workplace is to ask for less controlled circumstances, such that people feel able and willing to embrace the uncertainties inherent to playful living.”

Gamification also have its own challenges as well: it is complicated to be implemented (Bahr, 2022) and costly (Bright, 2021) and there has been few attempts to implement it in warehouse environments (Warmelink, 2020) and although it have some positive effects on performance and motivation, it can have some negative effects such as feeling of incompetence among some workers.

2.4. EEG

For evaluating personal interest, EEG (electroencephalogram) can be used which is a test to measure electrical activities in brains using electrodes. EEG has been used to evaluate different aspects of the human mind, especially in education, but in this case can measure if, and how much each combination is effective on each person. For example, in (Antonenko, 2010) cognitive load of each person can be continuously measured using EEG signals. In (Ni, 2020) did some attention analysis with mobile learners in different media such as text, text accompanied with graphics and videos. In (AlShorman, 2020) it was measuring how much learning and memory cognitive functions are affected by emotional stress using EEG. Since one of the most important KPIs in order picking process is learning, as it will decrease the

time needed for a picker to find a product and find an optimized rout etc., EEG can be used to measure the gamification experience efficacy on pickers and improve the process accordingly. EEG has been in use in other aspects of order picking in warehouses as well, such as the work of (Fiolka, 2020) that trained two commands with 13 participants to control AVG (automated guided vehicles) during an order picking.

2.5. Some possible scenarios:

Based on some major KPIs in previous chapters, the following scenarios are proposed as a starting point for creating more complex and sophisticated scenarios. Following assumptions are made in all scenarios:

- The warehouse has multiple sections for multiple categories.
- There are multiple workers
- Picking lists are unlimited

2.5.1. Scenario 1:

- Objective: routine order picking (same as any other general task)
- Operation: there would be a fixed cost assigned to each **single** order. Workers choose what order to pick based on bonus and their expertise on the order section(s).
- Output: physical picked goods

2.5.2. Scenario 2:

- Objective: team building
- Operation: there would be a fixed cost assigned to each task **batch** which needs to be fulfilled simultaneously. Workers team of 2 choose what order to pick based on mutual benefits such as **bonus** and their **combined** expertise on the order section(s).
- Output:
  - cooperation among members such as negotiating which batch accept and etc.
  - Knowledge sharing among participants on such as where goods are and how to pick goods in a more efficient way or which paths to choose

2.5.3. Scenario 3

- Objective: Training workers on different sections of warehouse
- Operation: Price of tasks for each worker is based on their picking history. If worker A only chooses picking lists in section C, bonus for sections A & B will be increased
- input: points
- Output:
  - physical picked goods
  - knowledge range on different sections of warehouse for an specific worker is extended

2.5.4. Scenario 4:

- Objective: expedite a specific order due to an emergency such as a VIP stakeholder

- Operation: price of tasks is increased (preferably with a time limit) for that specific order which motivates workers to choose that order
- Output:
  - Expedited order picking
  - Stakeholders' satisfaction (both worker and VIP)

2.5.5. Scenario 5:

- Objective: balancing human resources on different time of the day or days of the week
- Operation: price fluctuate (both announced and unannounced) if there is a shortage or surplus of workers in the system
- Output:
  - Workers would adjust their schedules based on bonuses they can obtain
  - There would be no more negotiations between parties on how to assign people to tasks which also affects total warehouse strategies

3. Methodology

3.1. Scenario measurements and filtrations:

Although there has been some work which measured the success of each of these elements individually, there has limited work on measuring combination of some of these methods together. This combination measurement can be done using warehouse KPIs in long term, and personal interest evaluations such as surveys in short term

Even if we aim to just decide whether each element be involved in a specific Scenario or not, we would be facing "2 to the power of elements number" of scenarios and we should also keep that in mind that each element have some subcategories of implementation which makes the total number of these scenarios even bigger. On the other hand, some of these elements are dependent and should be either used together or should not be used while another is being implanted. With limited resources, it is obvious that only a handful of Scenarios may be assessed. In order to overcome these challenges and design some mature scenarios, I suggest three steps:

1. Preliminary assessments: evaluation of some scenarios toward a set of goals in a framework to make sure that while each scenario addresses enough aspects of peoples' mind to motivate them, it does not focus only on one aspect.
2. In-depth analysis: After this preliminary assessment, we may continue with fine tuning elements with more staff engaging approaches such as simple methods like surveys and questionnaires and more complex methods like documentation of staff neuroscience activities during the scenario implementation simulation and multicriteria decision making algorithms.

These three phases can be show as:

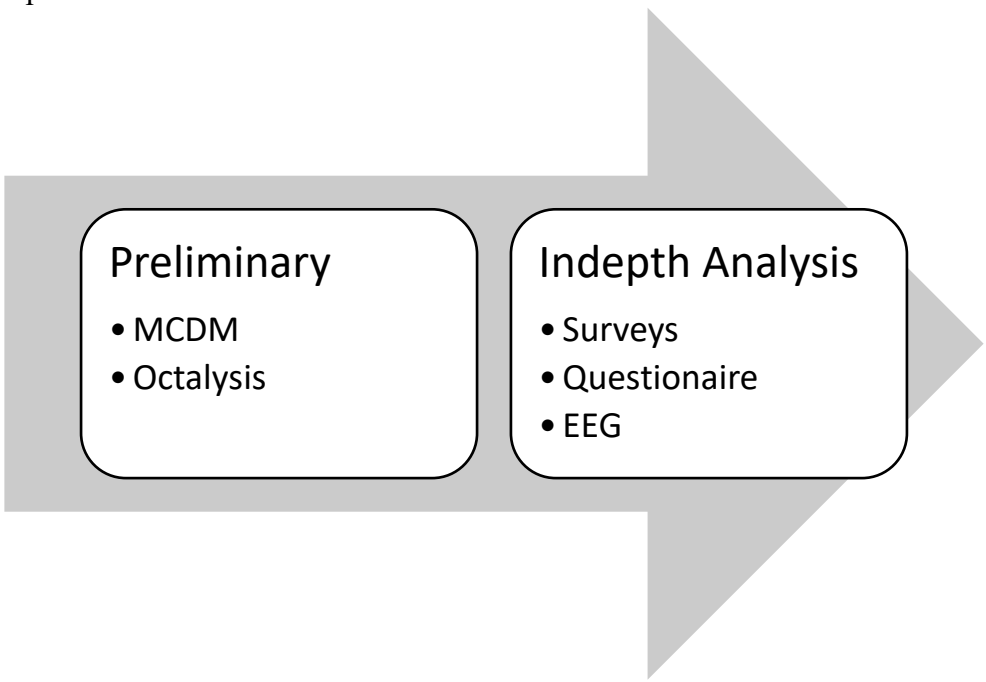

Figure 2. Two major steps of this proposal

3.2. Design and Preliminary assessment with Octalysis framework:

Some of the systems than can be used in these elements is:

1. Reward systems:
    a. should it be based on competition between pickers or should it be based on completion of each task. Administration teams are more inclined toward competition while workers are more inclined toward completion. (Ponis, 2020)
    b. How much should be the reward? Should it be static based on complexities such as (Chackelson, Errasti, & Tan, 2012) or use machine learning for an initial price and then increase it in increments until it is accepted by a picker.
2. Training systems:
    a. Customized training for each worker based on their skill and warehouse priorities
    b. Group training for customized groups of workers with different skillsets to share their unique knowledge
3. Task assignment:
    a. Tasks could be assigned to individuals based on their skills as a mandatory action or based on their choice with a fixed price (based on complexity model in (Chackelson, Errasti, & Tan, 2012)) or dynamic price (which is set with machine learning)

3.3. Real world KPI:

Although this section is measured last, this is exactly how each scenario design begins as well, as our main stakeholders are Real world warehouses which their goals are summarized in their KPIs.

Lot of the papers regarding proposing a gamification method in warehouses consist of different scenarios (Bright, 2021) with some static data, purely made up (Bright, 2021) or even without any data. Human systems are convoluted and every change in one of the elements or relations would affect others. There is almost no dynamic KPI measurement and most of the proposed methods in gamification of warehouses are totally theoretical (Bright, 2021). An onsite KPI measurement can be a big added value to these works.

Other than apparent operational aspects of gamification in order picking, training with gamification in logistics environments is another subject which some sources believed to be useful. (Teras, 2016) (Remi-Omosowon, 2016)

In (Casella, 2023) which reviewed 269 journal papers from 2007 to 2023, five main KPI categories is defined for order picking process:

- Technical KPIs, whose aim is to evaluate the operational aspects of the picking process
- Efficiency KPIs, focusing on productivity of the process
- Ergonomic KPIs, whose aim is to evaluate the efforts made by the picker during the process
- Computational KPIs, which express the speed in executing the computer program or algorithm
- Other KPIs, which group performance indexes not falling into the above categories

Although exact list of measured KPIs depends on the selected gamification scenario and gamification methods involved, but some of measurable KPIs from the same source are travel time, travel distance, waiting time, productivity, computational time, picking errors and ergonomic efforts.

3.4. Octalysis applications:

In (Sanchez-Gordón, 2016) authors investigated which human factors mentioned in ISO 10018 (ISO, 2012) can be mapped to Octalysis framework core drives in quality management systems. ISO 10018 Human factors are consisted of: Attitude and motivation, Education, and learning, Empowerment, Leadership, Networking, Communication, Recruitment, Awareness, Engagement, Teamwork and collaboration, Responsibility and authority, Creativity, and innovation, and finally, Recognition and rewards. Their findings showed that other than Motivation, other factors such as Communication, Education, Engagement, and Teamwork could be achieved using gamification and explicitly are in the framework. Remaining factors can still be mapped implicitly to the framework such as Awareness, Leadership, Networking, and Responsibility. There is only one human factor in ISO 10018, Recruitment, that is overlooked in the Octalysis Framework.

In (Marisa, 2020) authors measured student's motivation to participate in online class activities before and after using a gamification system which is designed based on Octalysis

framework. Findings are based on a questionnaire given to 419 students and each Octalysis core drive is assessed individually using Likert scaling survey questioning method. The result is all of core drives are categorized as contributing “High influence” to the students’ motivation.

In (Ewais, 2015) researchers assessed 12 stress management mHealth apps (mHealth apps aim is to provide medical support on mobile devices) using Octalysis framework on right brain (intrinsic) motivators. They investigated the extent of each app using left or right brain core drives, as well as white hat and black hat motivators (Octalysis top vs. bottom core drives). Findings were all these apps focus on white hat, right brain strategies which means users might not be interested to use the apps for a long time and recommended developers to implement more left core drives in their final products.

3.5. Expected outcomes

With selected scenarios being examined in a real-world warehouse order picking environment, with comparison on each real-world KPI before and after implementation of gamification, a road map will be generated to finetune the gamification app. For example, if social aspects of KPIs seem to be worsen after implementation, Social Octalysis Core Drives may be inspected and re-designed and tested using in-depth methodologies using Neuroscience applications until it reaches a satisfactory level.
(Ni, 2020)

3.6. Potential implementation Environments

Some potential retail customers in Iran have been already approached and initial understanding in goals reached for real-world implementation final step, but a potential customer in Germany could be a better candidate as it is physically more accessible, and results may be validated with a much higher confidence level. These groups will be reached out in future exhibitions as soon as the basic prototype of the game is released. On the other hand, for initial steps, simulated environments like university students or simple mobile games can be used to measure some specific aspects of the design and scenarios as well.

3.7. Research Proposal Objectives:

Main Objectives of this research is as follows:

1. Design, evaluate and select the best Octalysis gamification scenario based on Octalysis 8 core drives
2. EEG application to fine tune the selected scenario not just based on business needs and KPIs, but also consideration and implementation of moral values order picker’s voice
3. Final reports and findings of previous steps and defining to-the-point future research opportunities

3.8. Proposed planning

A Gantt chart is used to represent the projected progress based on current data and estimations. This chart is based on quarterly period and is consisted of all major tasks and

milestones to finish the thesis in 9 Quarters. Some tasks such as literature review is started already during the proposal compilation but need more in-depth work.

Table 2. Gantt Chart for the remaining nine quarters of this research proposal

Task Name	Start	End	2023-Q4	2024-Q1	2024-Q2	2024-Q3	2024-Q4	2025-Q1	2025-Q2	2025-Q3	2025-Q4
Upskilling technical domains	2023-Q4	2025-Q1	■	■	■	■	■	■			
in-depth Literature review	2023-Q4	2024-Q3	■	■	■	■					
Developing game scenarios	2024-Q1	2024-Q2		■	■						
Scenarios Comparison and nomination	2024-Q2	2024-Q2			■						
Order picking game development	2024-Q2	2025-Q1			■	■	■	■			
Game performance tests (Alpha)	2025-Q1	2025-Q1						■			
EEG in depth application and consultation	2024-Q3	2025-Q1				■	■	■			
EEG sample group tests (Beta) and Green Light	2025-Q1	2025-Q2						■	■		
EEG results validation and verifications	2025-Q2	2025-Q2							■		
Fine tune necessary changes based on EEG results	2025-Q2	2025-Q3							■	■	
Dissertation Compilation	2024-Q3	2025-Q3				■	■	■	■	■	
Thesis Defense and assessment	2025-Q3	2025-Q3								■	
Thesis Assessment review and editions	2025-Q3	2025-Q4								■	■

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