Title: Oxyquiz: Design of a board game to reinforce oxygen gas cylinder handling knowledge

Role of each author, if more than one

Puspendu Adhikari contributed to product development, article writing and testing of the game.

Soham Mohanty contributed to executing the workshop for testing and field validation.

Kashika Chawla designed the visuals of the game and took care of the overall aesthetics and contributed to executing the workshop for testing and field validation.

Tanishka Chavan contributed to executing the workshop for testing and field validation.

Advisor (Major Professor)

Vivek Kant, PhD is the guide of overall project including prototype approval, visual modification, testing plan preparation, draft reviewing and finalization.

• University or Institution Affiliation

Indian Institute of Technology, Kanpur

• Inclusive dates when study was conducted

May 2025 to Oct 2025

Analysis

• Study Objective

Accidents involving oxygen gas cylinders are a common phenomenon in several sectors. These require regular reinforcement of safe practices and associated knowledge for frontline workers, trainers, and safety managers. One entry is through a low-cost board game, enabling a means of augmenting knowledge about oxygen safety and awareness in non-formal settings. The game was designed *to augment* existing oxygen gas cylinder handling training, using rules, scenarios and bonus mechanisms to reward players. The key idea of the game is encouraging players to learn and reinforce knowledge concepts in relation to laws and statues about cylinder handling, both individually and collaboratively.

Inefficiencies in the handling of oxygen gas cylinders in various kinds of environments, as well as the procedural skills leading to accidents involving cylinder blasts and fires. While poor handling based on procedural skills is one dimension of the problem, additional dimensions include knowledge gaps such as lack of existing supply chains, understanding of regulations and existing best practices, amongst others.

Amongst these, a crucial dimension is the *support of knowledge of people* involved in management, handling, transportation, storage, and maintenance of oxygen gas cylinders. While traditional safety training continues to rely on safety rules and laws, the challenge of bringing these dimensions into everyday practice continues to prevail, especially in Low-and medium-income countries (LMIC).

One inroad into this issue is in approaching the problem of oxygen gas cylinder safety with low-cost serious board games for *augmenting the traditional training methods*, particularly in LMICs. Board games present a viable realization of three fundamental aspects: operationalizing abstract concepts, economic accessibility, and tangibility. Thus, developing serious board games can provide an important inroad into boosting the safety posture of organizations. Oxyquiz is a low-cost board game designed, using human-centric design processes, for safety managers and frontline supervisors to supplement their existing knowledge. This paper derives from the process of systemic mapping of challenges in the oxygen handling ecosystem. We extend the idea of serious games by demonstrating how traditional safety concepts can be used successfully with design-oriented methods to enable safe practices through knowledge generation and support.

Design

• Methodology

a. Oxygen gas cylinder handling ecology and associated challenges

The design process started with the recognition that inefficiencies in oxygen cylinder handling due to inadequate, at times, limited safety knowledge was one of the most high-impact and actionable points within the system. One way of addressing this was through game-based learning methods that provide a non-formal manner of learning that augments the traditional approaches of safety training. Thus, enabling the reduction of accidents, improvements in emergency response times, and ensuring the best compliance with safety protocols.

b. Game Design Core Ideas, Design process and Iterations

The game revolves around oxygen gas cylinder handling and workplace incidents across three different categories of work exposure: storage, transportation, and maintenance. Players were challenged to make decisions across the three categories of quiz questions, and are rewarded for safe actions, while unsafe actions are penalized. At the outset, the game was envisioned as a collaborative enterprise that will help the players not only individually but also collectively as a group. The game mechanics were specifically structured to encourage discussions as well as being challenged by others. This was with the view of supporting a more perspectival view when faced with real world scenarios. therefore, the focus was not simply to gain knowledge of oxygen cylinder handling but comprehend, how various situations could be analyzed based on different hazard conditions and possible actions. Thus, it would emphasize that safety of the oxygen cylinder sector is not an individual activity but a collabarative mindset.

The design process (Figure 1) that we used is derived from several serious game design frameworks. This process consists of five steps, starting with the outline of the scope. Next, the content was properly comprehended, and the game-based intervention was envisioned. Next, the game elements and gameplay were devised and tested. The design process was iterative with several rounds of prototypes and playtesting. The complexity and engagement of a game are influenced not just by the mechanics employed but also by the interactions among the mechanics and how they are specifically implemented. These factors play a vital role in shaping the overall play experience of Oxyquiz.

Figure 1: Serious Board Game Design Process followed in this article.

The team consists of graphic designers, product designers, interaction designers, instructional designers and safety professionals. The design process involved multiple iterations of design of game components, content, and gameplay (Figure 2). Out of these multiple iterations one prototype A emerged. This prototype was finalized and tested with designers and safety experts (Figure 3a,b,c,d). Based on the feedback and insights, further iterations were conducted to create prototype B which was tested by two different groups of safety experts. The final game component, content and gameplay are described in Integration Section.

Figure 2: Various iterations of game elements throughout the course of the design process

c. Prototype A (multiple iterations) and Evaluation I and II – formative evaluation with designers and safety experts-a group

Regular formative evaluation[1] was conducted to identify and finalize the materials along with the working mechanism as a part of the iterative process. During the development phase, Formative Evaluation I (Figure 3a) was conducted with the designers (n=5) to improve visual aesthetics, usability, communicational and instructional materials, and the gameplay. A second round of formative Evaluation II (Figure 3b) was carried out with the safety experts (n=8) to get their insights on content, learnability, and usability as a training aid. Based on the evaluations, a number of intermediate prototypes were created resulting in a final prototype B.

Figure 3(a): Evaluation I with designers. Figure 3(b): Evaluation II with Safety Experts-a group. Figure 3(c): Evaluation III with Safety Experts-b group. Figure 3(d): Evaluation IV with Safety Experts-c group.

[1] The ethics approval for human participant research was provided by the Institute Ethics Committee, Indian Institute of Technology Kanpur (IEC ID: IITK/IEC/2023–2024/II/25)

d. Prototype B and Evaluation III, IV: High-fidelity prototyping and summative evaluation with safety experts-b and safety experts-c group

In Prototype B, all the insights from the previous evaluation were incorporated. Next, the game was sent for summative evaluation (Figure 3c, 3d) with two different groups of safety experts in separate sessions (Evaluation III and IV; total n=46; Table 1, 2). The game was played for two hours by both groups. In each session, a small unit of four played the game. For summative evaluation, 31 questions, involving both qualitative and quantitative, were created as a questionnaire.

• Results (include illustrations and pictures)

Table 1: Participants' demographics for summative evaluation

Participants Age	Year group	Count	Percentage
Young Professional	18 to 35	17	37
Mid-age Professional	36 to 45	20	43
Senior Professional	46 and above	9	20

Table 2: Participants' position in their concern organization for summative evaluation

Participants Position	Count	Percentage
Junior Management (Up to Deputy Manager)	24	52
Middle Management (Manager to Senior Manager)	14	30
Senior Management (Chief Manager and above)	8	17

All participants filled a Pre-Play and Post-Play questionnaire in order to demonstrate the learning changes in relation to Aptitude of the participant, Support provided by the game, and Process of Oxygen cylinder handling. Figure 4 indicate the results of comparison of learning outcomes before and after the game. In addition, Figure 5 indicates the results of the participants response regarding the usability of the game elements.

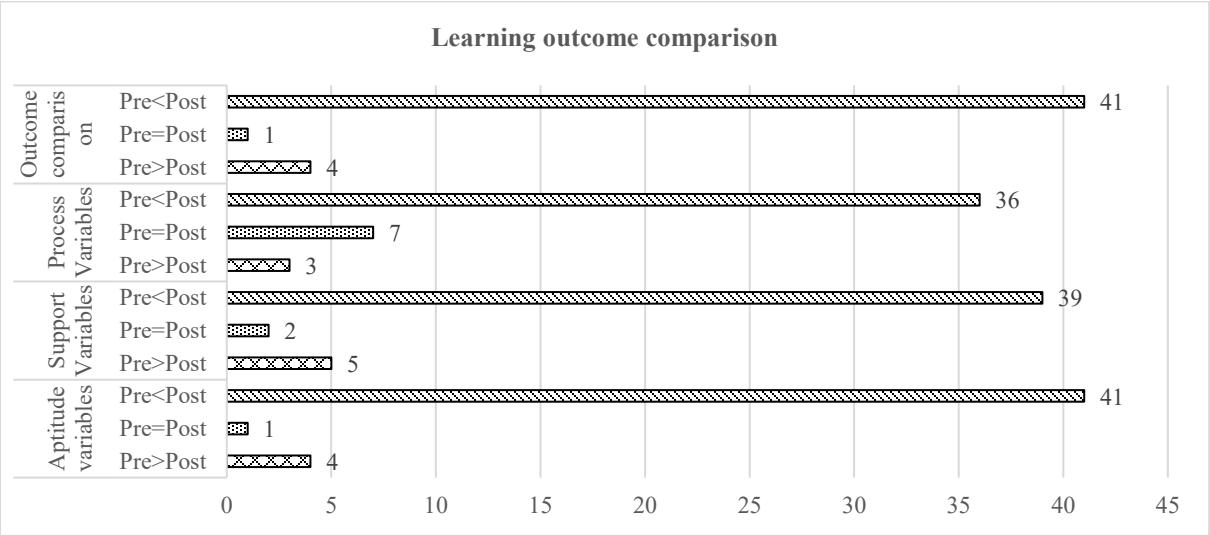

Figure 4: Comparison of Learning outcomes before and after playing the game

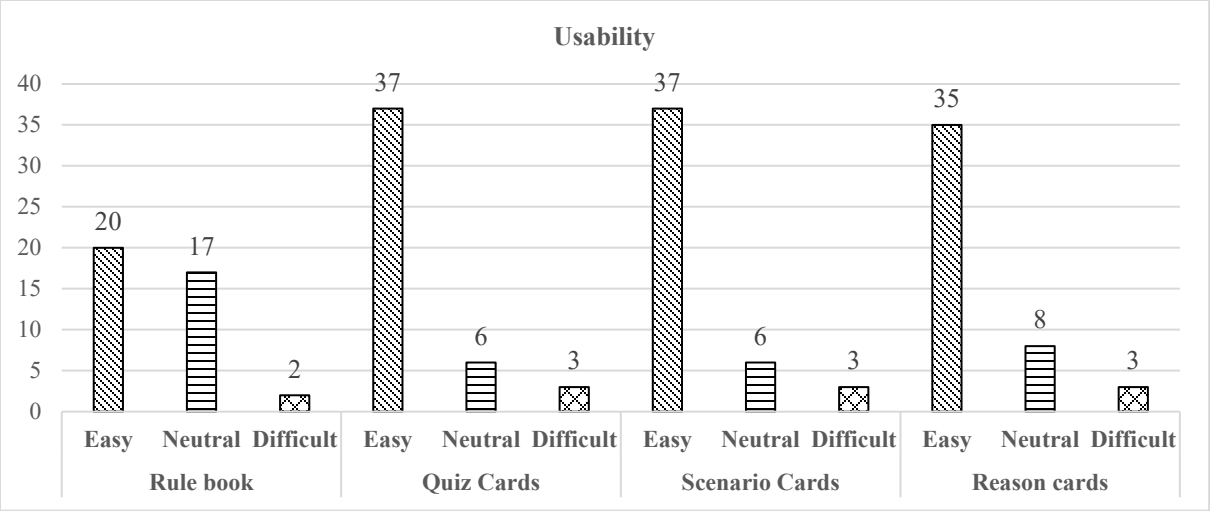

Figure 5: Participants' responses regarding the usability of the game elements

Integration

a. Final game components

Oxyquiz was conceptualized as a combination of a board game and a card game. The Oxyquiz game has four major components: *Wheel board*, *Quiz Cards*, *Scenario Cards*, and *Miscellaneous Cards (Bonus and Token)* (Figure 6). The wheel board, styled similar to a smooth freewheeling roulette wheel can be rotated by players. Once it stops spinning, the category on the wheel that will fall under the pointer will be used for further activity. Currently, the wheel consists of 5 categories: Storage (turquoise), Maintenance (orange), Transportation (sand yellow), Scenario (magenta), Miscellaneous (blue). The first three categories, respectively, are used as areas, where the players will be able to learn about the content related to statutory guidelines, safe operating procedures, and other related best practices. The category of scenario enables the players to engage in an understanding of a detailed scenario that they can discuss. The miscellaneous category involves elements such as *bonus*, *miss a turn* and *lose a token* which maintains the random dimension of gameplay. Once the wheel stops spinning, one of these categories on the wheel ends up under a green pointer, which is stuck to the gameboard base and is used for further steps in the game.

Quiz cards (60 in number) are a primary element of the game and are divided into three categories: Storage, Maintenance, and Transportation. They involve multiple-choice answer options questions (general quiz cards) and one-word answer questions (critical quiz cards), with related statutory regulatory information referring Indian Gas Cylinder Rules, 2016.

Next, 10 scenario cards constitute entities that serve for the discussion of critical scenarios explaining one real-life incident. Scenario cards are devised to be kept inside a flap that has the scenario explained. Reason cards, 12 in number, are provided for resolving the scenario round. They present options that the players can choose reason cards to explain the root cause(s) for the given scenarios under consideration.

In addition, 80 tokens are provided, and 30 bonus cards are provided in a box packaged for these two together. Token cards, as currency, are the winning criteria for the safety championship at the end of the game. Bonus cards are designed to introduce the luck factor of the game that could be used as a life-saving card during a crisis.

The visual elements of quiz cards, wheel, token, and bonus cards were placed in a manner to enhance a sense of visual appeal. The consistency in the styling of all the elements throughout the game for every game element and the contextual branding of Oxyquiz from the logo, font (ITC Avant Garde Gothic Pro), and color combinations was maintained to enhance the visual appeal and overall aesthetics.

b. Final game content

The game quiz questions cover the guidelines from different statutory regulations related to oxygen cylinders: e.g., Indian Bureau of Standards guidelines, the Gas Cylinder Rules 2016, and the Gas Cylinder Amendment rules 2022, to name a few. The questions are chosen based on specific clauses related to the Standard Operating Procedures (SOP) of oxygen gas cylinder handling, storage, and maintenance. A sample question involves "What is the interval for pressure testing of oxygen gas cylinders?" Options given include: "a)5 years, b)2 years, c)3 years, d)1 year." This question was derived from the IS 15975: 2020; Clauses 4.1.2 and 4.2. which states Standard oxygen gas cylinders must undergo hydrostatic pressure testing every 5 years. Another example could be a critical type question: "What is the minimum holding time period of applied test pressure on an oxygen gas cylinder during the Hydrostatic test?" This question was inspired by the IS 8451:2009 Section 11.3, which states that the permanent volumetric expansion of the cylinder is expressed after the cylinder has been held at test pressure for a minimum period of 30s. The critical type quiz card has no answer options. Therefore, the player has to recall the answer from their memory, making the critical-type questions harder.

c. Final gameplay

A minimum of three players and up to five players can play this game. Player 1 spins the wheel to determine the category (storage/maintenance/transportation/miscellaneous/scenario). Then Player 2 (to the left of Player 1) draws a card from the corresponding categorical deck and reads the question aloud for Player 1 to answer, and for others to challenge that answer, in clockwise order. If the first challenger (immediate left to the Player 2) forfeits their opportunity, the chance to challenge moves to the next player. Further, if the player who had spun the wheel initially uses their *Bonus Card* to obtain a Token instead of answering, the next player gains the opportunity to answer the question. There are three miscellaneous category outcomes on the board: *Miss a Turn* (Skip the next turn), *Lose a Token* (Lose 1 token, no question), and *Bonus* (Gain 1 bonus card).

In addition, the game also encourages a team-based approach to problem solving through scenario category. If the arrow lands on the scenario category on the spun board, any player can draw a Scenario Card and reveal the scenario on the sleeve of the envelope of the scenario card. This scenario has been carefully crafted in such a manner such that the players have to collectively discuss and give the answer by submitting *Reason Cards* (which contains possible reasons of incidents/accidents). The actual answers to the scenario question is inside the envelope and can be revealed only after all the players have collectively exhausted their possible answers for that scenario. In case all the players are able to find out all the possible answers to the scenario by using the reason cards, then each player will obtain a token. Alternatively, every player will lose a token for a single mismatch of reason card options with the answers. At the end of the game, the player with the highest number of tokens is declared the winner.

Figure 6: Game Assets- Spin wheel, Quiz Cards (with card contents), Bonus Cards, Reason Cards, Scenario Cards, Bonus Cards, and Tokens

• Discussion

Based on the design process and particular challenges in creating the game we found three major insights that can be used by game designers as pointers. First, while oxygen cylinder handling is often viewed as a manual and skill-based task that can be taught to others by training in terms of rules and procedures, the underlying knowledge-based dimension of *how to connect the various laws and regulations to the actual activity is often given less priority*. In many cases from our experience and discussions with safety experts in India, we have found that if the associated laws and regulations are cited then the acceptance of safe practices is more as compared to the cases where such support is not provided ("appeal to the ideas provided by the authority"). In our case of Oxyquiz, we aimed to supplement the general awareness of the players with the underlying laws and statues though the gameplay of collaborative learning.

The second dimension is of gameplay that can be extended to other games is the collaborative learning dimension. Oxygen cylinder handling is often viewed as a solitary or dyad-based skill and associated knowledge. However, our gameplay was designed to specifically create a collaborative environment, where one player can be challenged by others. This enables the entire cohort of players to collectively learn through discussions. This aspect of collaborative learning can be expanded to other safety sectors for knowledge-based training.

The third dimension from the game mechanics design that can be extended to other games is in the form of presenting scenarios where the player is put into cases where they have to collaboratively consider the issue. It is here that a game such as oxy-quiz really helps by making the players rehearse a situation by using the “reason” and “scenario”-based cards. The scenarios were carefully crafted while being drawn from various actual accident reports and being connected to various activities, hazards and conditions. This enables the players to consider the scenario in terms of perspective of other players as well as understand how scenarios develop due to a combination of acts and conditions which would then result in near-misses, injuries or fatalities. This game mechanics can be used for other industrial safety sectors to provide a richer appreciation of everyday scenarios that could lead to serious consequences. In the future, the game can be developed further and detailed measurements taken to provide a better understanding of knowledge acquisition before and after the gameplay

• Impact (describe specific benefits)

The analysis of the oxygen gas cylinder system is shaped by logistical, regulatory, and infrastructural challenges. Unsafe practices contribute to hazards and accidents, especially during emergencies. In response to these problems, Oxyquiz was formulated as a serious game highlighting interactive, choice-based collaborative experience. Its affordability, versatility, and consistency with safety protocols render it compatible with a wide range of industrial ecosystems. In conclusion, this project demonstrates how serious games-based concepts can create effective, scalable solutions that could be used for augmenting traditional safety training in LMICs.