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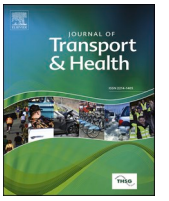

Game of (delivery) drones: A serious game exploring transport futures involving logistics drones with stakeholders

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ABSTRACT

Background: The use of uncrewed aerial vehicles (UAVs, also known as drones) in logistics is evolving. However, there have been few opportunities for people to explore and understand the implications. Existing studies focus on acceptance, yet it is unclear what people are being asked to accept. Using a board game approach, this study has sought to develop ways to involve non-experts in a more informed debate about logistics drones in their local area.

Method: A qualitative approach was adopted by developing a location-based board game to help a general audience explore the use of delivery drones and capture their views. Participants explore operational parameters, including ground risk (the probability of a drone hitting a person and injuring them if it fails in flight) and energy use while playing the game, and are prompted to respond to questions embedded within the game. Three game sessions with a total of 15 participants were completed.

Results: Participants were able to explore and test complex scenarios involving different drone routings and levels of ground risk and energy use whilst building shared knowledge and evoking social learning during gameplay. Participants exchanged views in a relaxed environment and began to explore the implications of the possible future use of delivery drones. Questions embedded within the game allowed people to share their concerns about health and safety, regulation, and where they thought drones should fly. Participants were aware of their knowledge limitations, and it was evident that several misconceptions about delivery drones are emerging.

Conclusion: The board game has proved useful in involving people and capturing an in-depth understanding of their views. It is an engaging approach to involve stakeholders in the planning process, creating an artefact that can be adapted to other locations and used by other researchers and practitioners.

1. Introduction

The UK government is advancing plans for Urban Air Mobility (UAM) that include the use of Uncrewed Aerial Vehicles (UAVs, also

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known as drones) for use in logistics (i.e., payload delivery). This has the potential to bring about significant changes to local environments due to flying in lower airspace with associated noise, visual intrusion, and potential risks with health implications.

Public awareness of delivery drone capabilities is low, with most knowledge gained through mainstream media (Reddy and DeLaurentis, 2016) or through information provided by third parties portraying delivery drones as being for the public good (for example, helping the health service), saving time and energy, and reducing congestion. However, the comparative advantage of using drones is far from clear (Oakey et al., 2022). There is little clarity on how delivery drones will operate in the future, including specific use scenarios, operational parameters, and locations, making it difficult to explore stakeholder opinions (Smith et al., 2022a). People's views are also influenced by their experiences of existing UAVs such as hobby drones and may find it hard to understand the implications of a technology that is largely invisible beyond a few niche trials. Delivery drones would play a significant role in people's lives if they were to operate in towns and cities where people live, and closer attention needs to be paid to stakeholder views, and opportunities afforded for involvement in policy formulation. Involving stakeholders in a debate around delivery drones is a challenge as they are not high on the public-facing political agenda, nor are they present at a local level (Smith et al., 2022b).

These challenges call for a shift from traditional public engagement approaches to techniques that actively involve people in transport futures so that the public can inform the debate about future policies and regulations, including where delivery drones fly. In this sense, serious games offer advantages as they have the scope to involve diverse stakeholders through their novelty and the element of fun (Khoury et al., 2018). They can also immerse people in complex problems (Aubert et al., 2019), like determining transport futures which trigger emotions (Marini et al., 2018) and motivate debate (Rodela et al., 2018). This paper aims to demonstrate the value of a board game to explore an unknown transport future involving delivery drones. We argue that a game-based approach will address the abovementioned problems and that the approach can be applied to other types of Advanced Air Mobility (AAM) technology and other areas of transport planning.

The paper begins by explaining the opportunities afforded by game-based approaches to the transport field before describing the game development, approach to gameplay and data collection. This is followed by a brief discussion of initial findings from gameplay sessions. The paper concludes with a discussion of the value of the approach for research, policy, and participants.

1.1. Serious games for public involvement

Participatory approaches involving stakeholders have been established for some time in research (Parker et al., 2002; Reed, 2008). Their benefits include enhancing the credibility and inclusion of diverse perspectives among stakeholders, inclusion of non-scientific knowledge and experience, and widening the basis of support for the implementation of solutions (Van der Wal et al., 2016). The participatory process can lead to amplified stakeholder dialogue and provide feedback on choices, actions, and consequences in a simulated environment (Jiggins et al., 2007). However, traditional approaches can lead to power asymmetries as participant expertise varies and some participants are reluctant to voice their concerns in group environments (Rodela et al., 2019).

Serious games are described as a participatory tool used to engage the public in a debate or activity (Rodela et al., 2019). The educational value of serious games is beyond entertainment (Susi et al., 2007) and proves to be a useful tool to trigger group discussions (Ampatzidou et al., 2018). Serious games have four general characteristics that highlight their potential usefulness: universal language, flexibility to explore uncertainties and complexities, ability to facilitate learning, and the opportunity they provide for the timely collection of relevant data (Olejniczak et al., 2020).

Games can enable the exploration of imaginary spaces and scenarios, and players can form opinions while interacting, enhancing their critical thinking (Gomes et al., 2021). An advantage of using a game is its ability to simulate an environment when designed and executed with precision, engaging every participant in a complex scenario in which all hold a stake in proceeding (Bridge, 2014). Board games have been categorised as serious games for learning as participants sit in a face-to-face environment and are challenged to achieve the goals of the game (Cheng et al., 2020). Serious games involve goals, rules, a feedback system, and participation (McGonigal, 2011), though it is important to recognise differences in the intended game use (such as games for data collection vs education; training vs transformative change) as it is likely to impact the implications of game development, testing, and evaluation (Rodela et al., 2019).

The social learning process applies to the game described in this paper. This is the process in which individuals learn from each other in social settings (Reed et al., 2010). It is defined as 'learning that occurs when people engage one another, sharing diverse perspectives and experiences to develop a common framework of understanding and basis for joint action' (Schusler et al., 2003). By observing and interacting with each other, players also develop shared values (Kapp, 2012). While social learning typically focuses on bringing about social change, this was not the intention of the game described in this paper, rather the focus was on the first step in the social learning process where understanding takes place (Reed et al., 2010). Within the context of social learning, knowledge co-creation plays a part where individuals learn and collaborate based on explicit and tacit knowledge (Jean et al., 2018a).

Explicit knowledge is that which is documented (e.g., knowledge of certain legislation) (Roux et al., 2006), while tacit knowledge is based on personal experiences (Polanyi, 1966). There are four stages of knowledge co-creation: socialisation (transfer of knowledge between individuals through direct interactions); externalisation (dialogue and creation of shared knowledge); combination (capturing and dissemination of new knowledge); and internalisation (adoption of externalised knowledge into individual's own thinking) (Nonaka and Takeuchi, 1995; Jean et al., 2018a). Research involving the use of serious games has suggested that these games have the potential to engage the four stages of the knowledge co-creation process (Jean et al., 2018b; Barreteau et al., 2007), fostering relationships between participants and allowing for the sharing and creation of new types of tacit and explicit knowledge (Akkerman and Bruining, 2016).

Current research exploring public views on the use of drones has focused on knowledge, concerns, and the degree of acceptance

towards the technology (see for example, Aydin, 2019; Eiβfeldt et al., 2020). Research on acceptance adopts a deficit model that questions the public's ability to provide considered views and assumes that if people are better informed, they will accept and use new technologies (Joffe, 2003; Sherry-Brennan et al., 2010; Stilgoe and Cohen 2021). In contrast, studies that have contextualised and situated new technologies in places (Batel and Devine-Wright, 2015) bring new issues to the fore without the need for questions that prompt specific issues (Sherry-Brennan et al., 2010). This approach requires creating new tools to build an understanding of logistic drones and their operational parameters providing a space for debate and reflection that is not guided by trying to achieve acceptance of the technology.

2. Methods

2.1. Design

A board game has been developed to provide stakeholders with a space to share ideas and reflect on the use of logistics drones (referred to as delivery drones in the board game) in their local area. The game was designed to raise interest in delivery drones, highlight some of the operating considerations (an element of education), and involve players in a discussion which can be captured as part of data collection to inform debates about governance and regulation. This builds on a game intervention design by Khoury et al. (2018) inspired by the Socratic method to encourage players to question and challenge their assumptions and probe the underlying beliefs or values upon which each participant's statements, arguments and assumptions are built, therefore fostering critical thinking. The approach was inductive and allowed views to emerge to build theoretical insights from public involvement and to address the deficit perspective adopted in other studies. A qualitative approach was embedded through questions built into the game design. The objective of the board game was to consider the route, ground risk (the probability of a drone hitting a person and injuring them if it fails in flight) and energy used, to make an efficient drone delivery. The components included a game board, risk meter, energy tokens, mission cards, flight update cards, and comment cards.

The board game development is described in 5 phases (see Fig. 1) that took place over a period of six months (June 2022–November 2022).

To increase the accessibility of the game, the board game was contextualised to the players' local environment to make the energy, risk, and operational considerations relatable, and gameplay decisions more intuitive. To start the board design process, a map of Bournemouth, Christchurch and Ferndown, UK was scaled, and locally recognisable suburbs were identified along with landmarks that would make it easy for players to recognise places on the board game map. These landmarks included parks, nature reserves, schools, town centres, hospitals, industrial estates, and the beach.

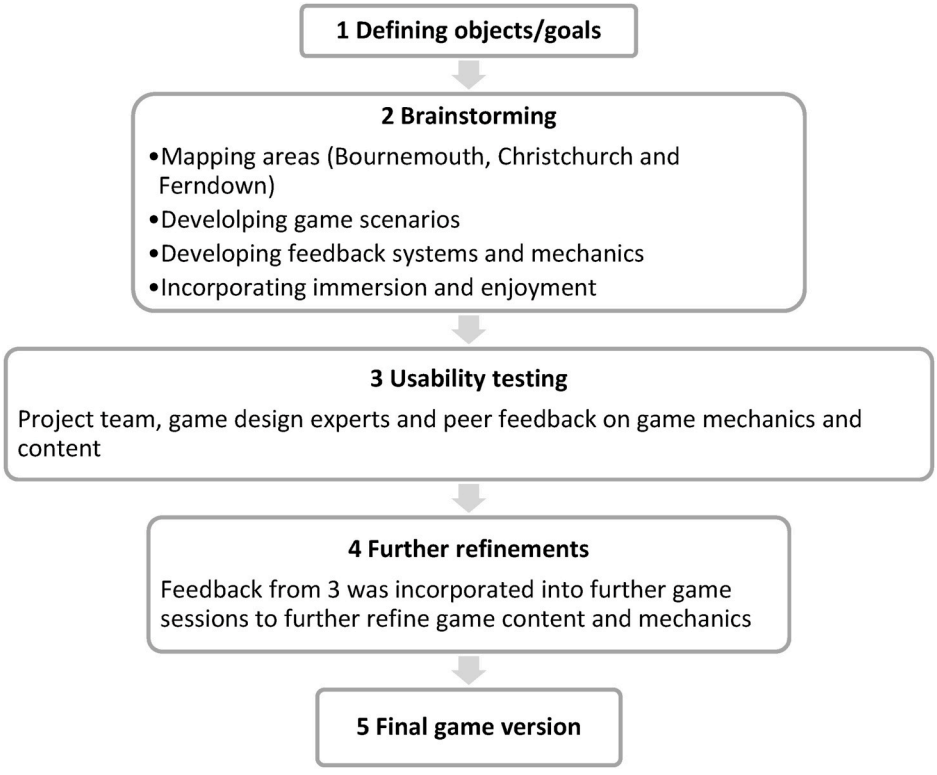
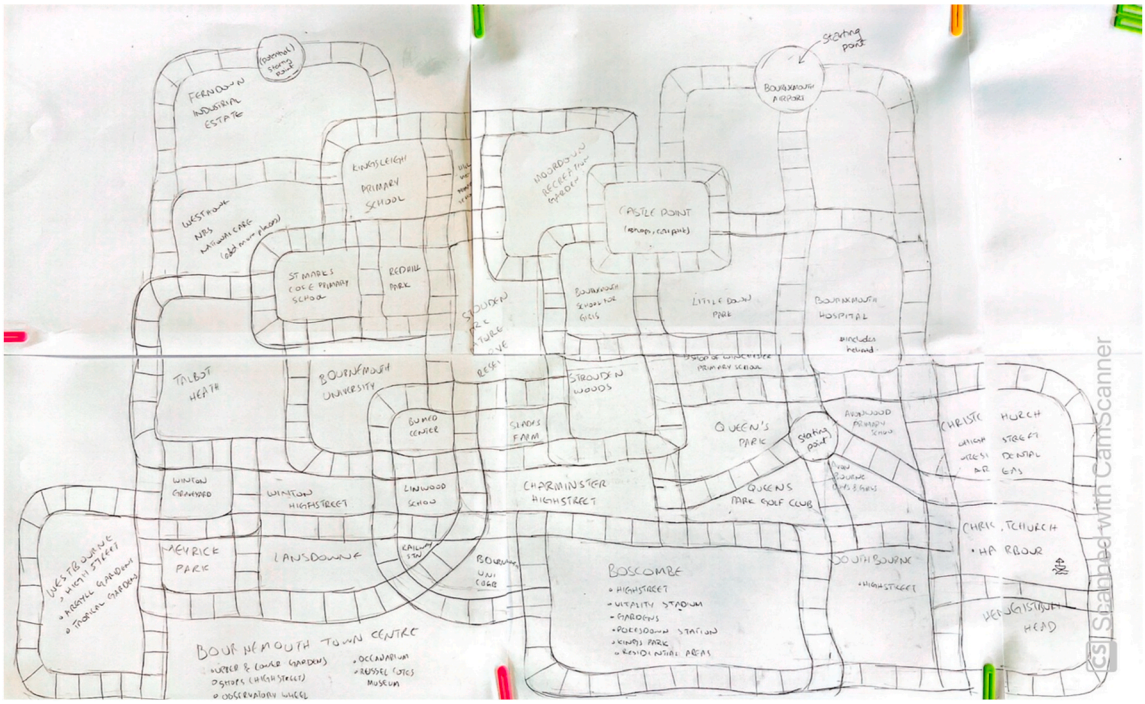


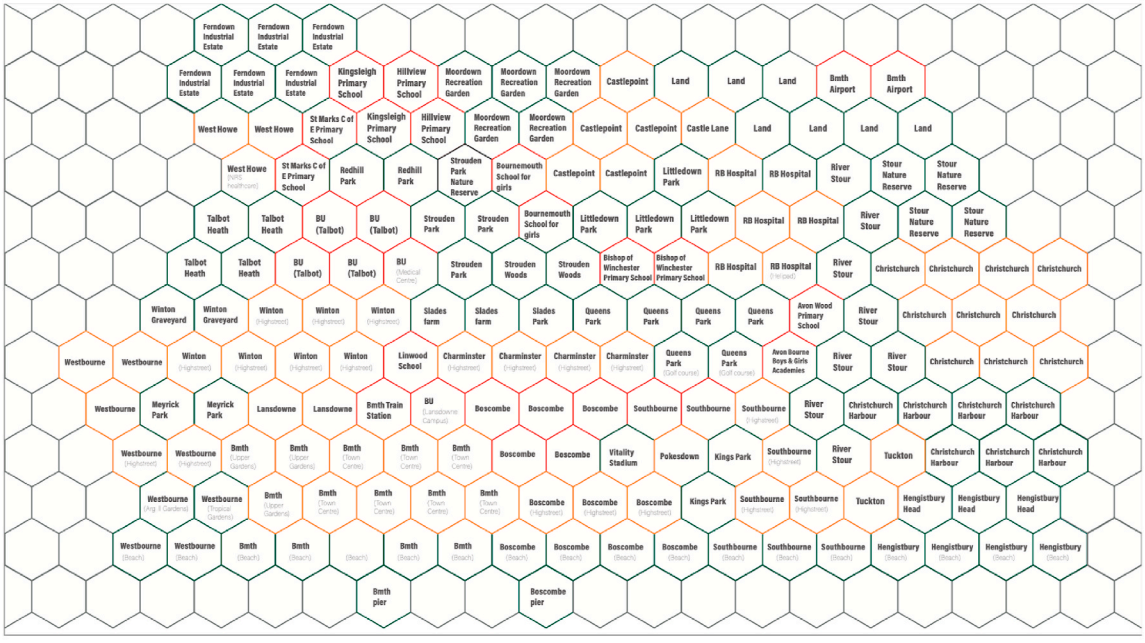
Fig. 1. Description of phases of designing the board game.

The first iteration of the board game map displayed a predefined path for players but was later changed to the use of hexagons (see Fig. 2) that allowed the players' autonomy to move across the board and plot their routes.

Each hexagon is marked in either red, orange, or green to identify levels of risk. This was based on a ground risk model developed by Pilko et al. (2023) which estimates the probability of a drone failing in flight and causing a fatality using spatiotemporal population density. The board cannot represent the temporal variation and presents risk at a broad level in red (as high risk, associated with flying over heavily populated centres), orange (as medium risk) and green (as low risk, associated with flying over sparsely populated areas).



Version 1: Predefined path



Version 2: Use of Hexagons instead of a predefined path

Fig. 2. Versions of the board.

This enables players to think about risk as they move across the board.

The next step involved identifying game mechanics (Table 1). A total of 192 game mechanics were identified on Board Game Gee (2005). To keep the game intelligible and intuitive, the simplest ones were chosen after multiple brainstorming sessions with experts in game design. These mechanics were chosen to align with the context and aim of the game while keeping it accessible to the target audience in mind i.e., the public.

Three sets of card decks were created to enhance the gameplay mechanics. These include mission cards and flight update cards.

2.1.1. Mission cards

Two sets of four mission cards were designed to play two, 20-min rounds. The missions for the first round (Fig. 3) were straightforward for players to familiarise themselves with the map and understand the game mechanics. These missions were designed to keep a low risk, and 12 turns in total so players can have an 'efficient' drone flight, but ultimately players have autonomy over what route they take, how much energy they use and how risky their drone flight is. Players could then proceed to play the more complex round two.

Round two was designed for players to have more freedom in plotting their drone flight path and to reflect more on the risk and implications for their routes. Players were prompted to state what sort of deliveries they plan to make along with their reasoning, so players and researchers can understand their rationale.

2.1.2. Flight update

Flight update cards (Fig. 4) were designed for players to get feedback on their drone flight while developing an understanding of the operational parameters of drones. Players can lose or gain energy points, move forward, or miss a round. A total of 69 flight update cards were used to avoid repetition which could be boring for players. These cards were shuffled and ordered in a way to maintain an appropriate balance of positive (48 cards) and negative cards (21 cards) so players are not penalised too much and are able to complete their missions.

2.1.3. Comment cards

Landing on a hexagon marked with a speech bubble prompted players to pick up a comment card (Fig. 5) that aimed to initiate a discussion between all the players. This functioned rather like a question in a focus group. All players must answer the question posed rather than just the player who picks up the card. A total of 18 comment cards were used.

2.1.4. Risk and energy

At the start of the game, players were provided with a risk meter and energy tokens (100 total) (Fig. 6). The risk meter displays a 'subjective' risk ranging from green (0) to red (15) that provides players with a simplified idea about the concept of ground risk. The risk meter was moved according to the colour of the hexagon the player chose to move to (+2 for landing on red, +1 for moving on orange, and no movement if landing on green). Players ending up on red (15) on the risk scale would have failed the mission but still be able to play till the end of the round.

Players lose 5 energy points each turn and fail the round if they run out of energy. They can also earn energy during gameplay through the flight update cards. The risk meter and energy tokens numbers were set to achieve balance in the game so that players needed to reflect on route decisions to avoid too much risk or running out of energy. Direct routes typically involve more risk but use

Table 1
Board game mechanics (Board Game Geek, 2022).

Mechanic	Description	Application in the board game
Action points	Each player has several points per turn to spend on actions as the player chooses.	Players are provided with a total of 100 energy points to complete the mission.
Board space abilities	Certain spaces on the playing field produce certain effects when a player lands their piece on them.	- Players pick up a feedback card (Flight update) each turn. - Players pick up a comment card if they land on a space with a speech bubble icon.
Deadline	Players must complete their goals before a set amount of turns or before a certain time passes.	- Players are given limited energy to complete a mission. - Players are provided with a limited amount of risk to complete missions. Ending on high-risk (15) will fail the mission.
Differing player goals	Players are not directed to achieve one goal but are given autonomous goals.	Players are provided different missions to play and can decide their goals.
Individual decks	Players draw from separate decks.	Flight update, comment cards.
Press your luck	Players can raise the stakes by taking bigger and bigger risks with large payoffs but with disastrous consequences.	Players can move via higher-risk areas, trading off risk to make their route shorter and using less energy. Consequently, players complete at a higher risk.
Race to end	Players compete to reach a certain ending point on the playing field before the other does.	Leader board maintained for fastest delivery. Mission failed/completed cards handed out at the end.
Resource budget	Players are provided with a finite resource and urged to spend it efficiently on game pieces or privileges.	Finite resources: - Energy (100) - Risk (15 boxes)
Rewards	Instant feedback systems that may be a summary of the learning activity that a player finishes or a form of feedback.	Players gain energy depending on the feedback card.

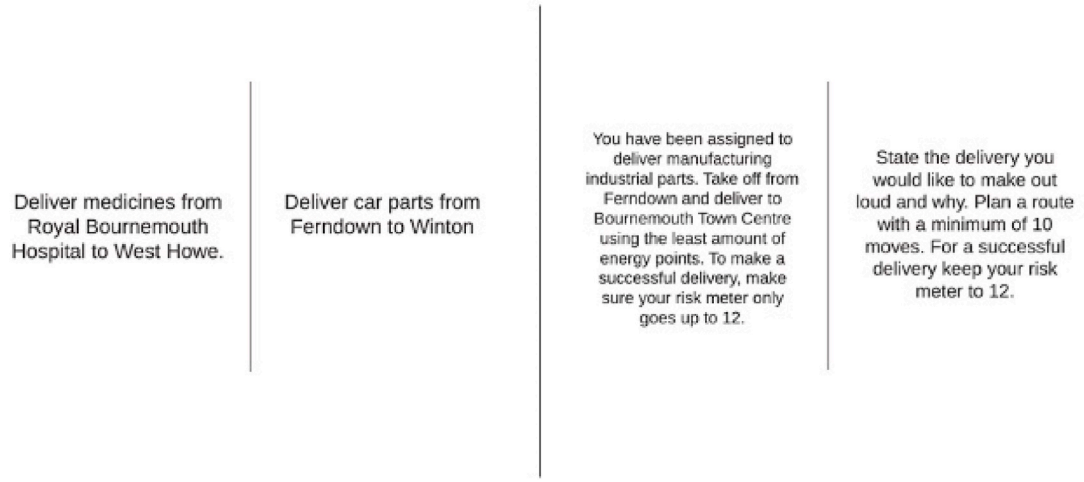


Fig. 3. Example of mission cards (Rounds 1 and 2).

Fig. 4. Example of flight update cards.

Fig. 5. Examples of comment cards.

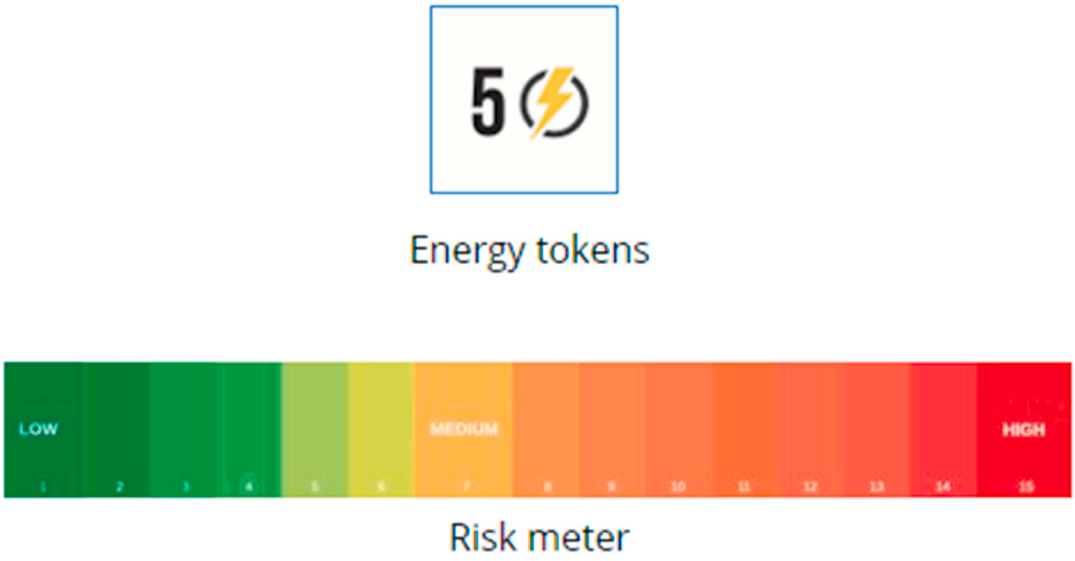


Fig. 6. Energy token and risk meter.

less energy.

2.1.5. Enjoyment and immersion

Rogerson et al. (2016) recommend factors such as sociality, intellectual challenge, materiality and immediate play environment contribute to enjoyment. Have been used in board game design. These factors have contributed to enhancing player experience in this board game, for example: These factors have been used in the design of the board game to enhance player experience for example.

1 Sociality: participants are prompted to have discussions during the game, therefore, enhancing the social experience of play.
2 Intellectual challenge: participants are involved in strategic thinking by plotting routes on the map keeping risk to a minimum and understanding the implications of a drone flight.
3 Materiality: attention has been paid to the design of the game components including the game pieces (3D-printed drones). Energy tokens act like money where players aim to save rather than expend energy and this contributes towards the 'winning' aspect of the game, therefore creating a competitive environment.
4 Immediate play environment: play settings to be well-lit comfortable spaces with food and water available.

The third phase of development involved testing the low-fidelity prototype with the project team and experts in game design to further refine the game experience. Alterations were made to some mission cards that were too difficult to complete and feedback cards were updated to drive competition between players, and the scale of risk (initially only set to 10 boxes) was altered so players could finish their missions. It was noted during these sessions that the rules had to be simple and direct for ease of play and to complete the two-game rounds within a restricted timeframe. The fourth phase included playing with non-experts in game design and delivery drones to establish the playability of the board game. At this point, the board design was finalised (Fig. 7).

2.2. Research implementation

Each board game session was 90 min long and was divided into 3 phases.

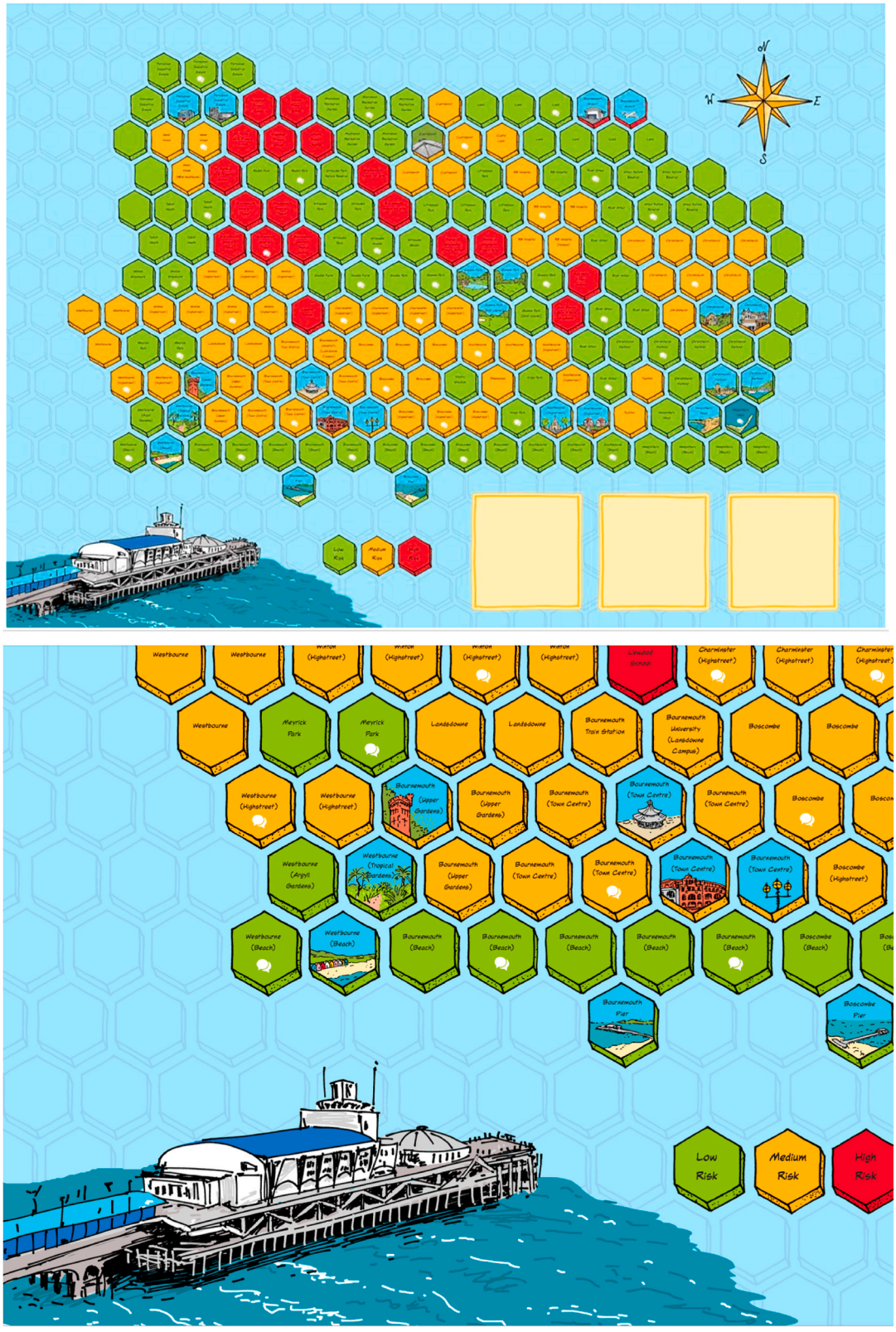


Fig. 7. Above: Final version of the board, Below: Zoomed in to show detail.

2.2.1. Introductory phase

Players were given an introduction about the research project and the board game instructions were explained. They were then asked to fill in a pre-game survey that was used to collect demographic data.

2.2.2. Exploratory phase

The exploratory phase was divided into two 20-min rounds of gameplay. The researcher played the role of the moderator during this phase which involved handing out cards, monitoring player movements on the board, answering any questions the players had, managing the group discussion, and encouraging further debate.

2.2.3. Debriefing phase

Based on Khoury et al. (2018) the final phase involved debriefing the players which allowed them to reflect on their game experiences and the outcomes through interaction with other players and the researchers. Players were also encouraged to ask questions which allowed the researchers to dispel any prevailing misconceptions.

2.3. Data analysis

The gameplay sessions were audio recorded to capture the players' discussion throughout the game and during the post-game debriefing. Researchers also made notes recording their observations of the gameplay. The audio recordings were transcribed, and initial notes and memos were made to identify key concepts. Following this, more detailed coding was undertaken, orientated into themes related to gameplay process and interaction, topic areas covered, and players' assumptions.

3. Results and discussion

This paper sets out to demonstrate the value of a board game to explore an unknown transport future involving delivery drones. Initial results are reported here from the fourth design phase which involved playing with non-experts in game design. Three gameplay sessions took place in a café located in Bournemouth as part of the ESRC Festival of Social Sciences on November 2, 2022. These sessions were designed to test the game with a general audience and explore the value of the game as a tool to involve participants in a transport future that is yet to exist. One session involved participants from a local exercise group (Group 1) known to one of the researchers, whilst Groups 2 and 3 involved participants from the University of the Third Age who are interested in being involved in research projects (see Table 2 for participant demographics). An Eventbrite page was set up and invites were sent to the members of the University of the Third Age. It was made clear that no prior knowledge of delivery drones was required to play the game. The recruitment led to the involvement of an older age demographic but provided a diversity of experiences and perspectives which demonstrates the value of the board game. Further work will involve other groups. Group size varied from 4 to 6. Depending on the number of participants, players were either put in pairs or played on their own. Given the time commitment needed to play the game, participants were recruited in advance to attend a pre-arranged game session and were offered a financial incentive of £15 commensurate with the 90-min time. These gameplay sessions established the viability of the game.

Players held very limited knowledge about delivery drones prior to gameplay and confirmed that they had largely heard of them in movies or news media, for example, drones being used for criminal use such as delivering drugs into prison and the use in trials moving medical items. Research has also demonstrated that the public relies on information from third parties therefore their experience with the technology and its risk is limited (see for example, Renn and Benighaus, 2013; Bajde et al., 2017; Reddy and DeLaurentis, 2016).

A low-stake environment encouraged positive interactions with the game and other players (Table 3). Jean et al. (2018a) observed

Table 2
Demographic data (split by group).

Age	Gender	Education
Group 1		
55–64	Female	University degree or equivalent
55–64	Female	O-Level/CSE/GCSE
55–64	Female	Higher National Diploma or equivalent
55–64	Female	A-Level or equivalent
Group 2		
65–74	Male	O-Level/CSE/GCSE
65–74	Male	Postgraduate qualification
75–84	Male	University degree or equivalent
65–74	Female	A-Level or equivalent
65–74	Female	Postgraduate qualification
75–84	Female	O-Level/CSE/GCSE
Group 3		
65–74	Female	Postgraduate qualification
75–84	Female	A-Level or equivalent
65–74	Female	A-Level or equivalent
65–74	Female	No qualification
75–84	Female	University degree or equivalent

Table 3
Evidence of Quality of interaction indicators (Adapted from Jean et al., 2018a).

Indicator (Jean et al., 2018a)	Description	Evidence in game using participant quotes
Consensus between pairs/group	Participants agree on where to proceed on the map keeping risk and energy in mind.	"Let's go there so we can come across … yeah? Plan straight across and have energy. Yeah?" ***Male Participant 4, Group 2***
Collective/ individual reflection	Sharing of ideas in response to comment cards, reflecting on a flight update card as a consequence of their move, reflecting on the implication of risk leading to a discussion about health and safety. Sharing their assumptions about drones.	"What is the risk? When you say high risk, is that collision with something?" ***Female Participant 3, Group 2***
Anecdote and opinion exchange	Sharing of ideas about how drone paths and deliveries would be made. Opinion sharing about their concerns in relation to drones.	Discussion between Group 2 participants: "We've got distribution centres. You can also have delivery centres and like … drivers on motorbikes could deliver the last 200 yards." ***Male participant 4, Group 2*** Or could they drop with something like an Amazon point where you pick it up from an Amazon point?" ***Female Participant 5, Group 2***
Shared laughter	Moments when the participants laughed together.	Discussion between Group 3 participants: "Delivery drones flying over my house. Makes me feel? ***Female Participant 5, Group 3*** Excited. Cause I'm expecting a delivery **(Laughter).** ***Female Participant 1, Group 3*** Totally indifferent. ***Female Participant 5, Group 3*** Angry. ***Female Participant 2, Group 3*** Terrified. We've got a gamut of emotions!" ***Female Participant 3, Group 3***
Tacit knowledge transfer	Opinions were shared between participants, reflecting on their personal experiences with drones.	"If they're noisy. Like the little planes that I get over my place from the airport. They really are disruptive. They make so much noise … because I'm on the flight path." ***Female Participant 1, Group 3***
Explicit knowledge transfer	Debrief with the facilitator, dispelling myths or assumptions that participants may have.	Group 1's debrief example: "How much can they carry though?" ***Female participant 1, Group 1*** "It depends on the type of drone." ***Researcher***

that interactions are necessary for the socialisation stage of knowledge co-creation and that quality interaction between participants is important. They developed indicators to describe the quality of interactions between players which have been evaluated for this game.

As suggested in the literature, the value of these interactions was supported by game mechanics (see for example, Jean et al., 2018a), and the level of difficulty corresponded with the audience (see for example, Biermann, 2011). While the game provided information about delivery drones, players also learned from each other through the exchange of information during gameplay as per Van Bilsen et al. (2010).

The analysis presented in this section focuses on how the board game encouraged players to understand complex scenarios, such as the operational parameters of delivery drones, the co-creation of knowledge and the game mechanics in action enabling reflection and debate among players.

3.1. Illustrating complexities

Research has demonstrated the importance of games imitating reality as otherwise user motivation may drop and players may become disengaged (Rodela et al., 2019). Players were observed making route decisions related to risk and energy and recognised and identified with local areas on the map. Rodela et al. (2019) suggest that using near-world circumstances makes the gameplay more intuitive, therefore playing the game contextualised to the location where players live contributed to their interactions being more meaningful (Rodela et al., 2019) such as:

> *Slade's Farm, I don't know …* ***(Female Participant 1, Group 3)***
>
> *That's where the Scout camp is!"* ***(Female Participant 2, Group 3)***
>
> *"Yeah. You're right. If I move into red, what happens?* ***(Female Participant 3, Group 1)***
>
> *Oh, does it matter?* ***(Female Participant 2, Group 1)***
>
> *Busy yeah, Lansdowne …. Super busy."* ***(Female Participant 3, Group 1)***

Players were conscious of landing on high-risk areas and kept energy in mind which enabled them to reflect on trading off a quick route with higher risk and using less energy or taking a longer route to avoid risky areas and using more energy. This enabled them to explore the interrelationships between the route, risk, and energy. This is illustrated by the following examples of players plotting their routes.

"Some people might say, okay, the quickest route is, is the best, so it wouldn't matter if you're going through a red spot, whatever. You just get there. Yeah. As fast as you can. Um, but I think we've been very mindful of the fact that we are trying to be energy efficient. Um, and staying away from populated areas." ***(Female Participant 2, Group 3)***

"We'll have to go red one way. ***(Female Participant 5, Group 2)***

No, you won't, you can go green. ***(Male Participant 4, Group 2)***

No, that is such a long way." ***(Female Participant 5, Group 2)***

Players learn by acting and experiencing the consequences of their decisions and, as Mayer (2009) suggests, through feedback mechanisms embedded within the game providing participants with a safe space to test out scenarios.

3.2. Knowledge Co-creation and reflection

The gameplay permitted players to understand the consequences of their decisions, which as Devisch et al. (2016) suggest supported reflection. Comment cards embedded within the game produced some intriguing discussions and proved useful as they prompted players who reflect on a collective as well as an individual level. This facilitated effective dialogue and exchange of ideas across a diverse set of people (see for example, Geurts et al., 2007) (Geurts et al., 2007) and, as indicated in research by Jean et al. (2018a), created opportunities to allow the co-creation of knowledge. (Jean et al., 2018a). This allowed for the stages of knowledge co-creation to take place as illustrated in Table 4. Player discussions revolved around recommendations for regulation, health and safety, and assumptions about the use of drones.

3.2.1. Recommendations for regulation

Players reflected on their preferences for drone landing and take-off sites. In their conversations, they imagined and proposed amalgamating other logistic modes with drones and using designated depots, so they do not invade private spaces. Comment card prompts included *'My recommendations on forming regulations around delivery drones would be … '* and *'Delivery drones should only be allowed to take off and land in places such as … '*. An interaction from Group 3 illustrates this well:

"So, take off. Well, there'll be some kind of depots? ***(Female Participant 1, Group 3)***

But again, it's delivering … Your [person] is vulnerable and wants it on his drive. ***(Female Participant 2, Group 3)***

… it's a bit pointless if you're gonna put it in a lorry and drive it somewhere before it takes off. ***(Female Participant 3, Group 3)***

Yeah, it's gotta be … ***(Female Participant 2, Group 3)***

… I could think of places where I wouldn't have it land. So, schools … around school would be, um, a no-no. ***(Female Participant 1, Group 3)***

Why? What's your rationale for that one? ***(Female Participant 2, Group 3)***

Drones? Maybe drones shouldn't be delivering to schools, otherwise the kids would be ordering … Certainly not crowded places like a beach. You think of the beach on the day." ***(Female Participant 1, Group 3)***

You need a body like the CAA that covers aviation." ***(Female Participant 3, Group 3)***

During the discussion, player concerns were less marked about drones flying over public spaces such as parks, roads or streets as compared to spaces such as private gardens or near residential buildings. These discussions enabled reflection on envisaged flight paths and airspace control, for example:

Table 4
Evidence of knowledge co-creation during gameplay (Adapted from Jean et al., 2018a).

Knowledge co-creation stage (Jean et al., 2018a)	Requirements (Jean et al., 2018a)	Achieved by board game?	Evidence
Socialisation	Direct interaction	Yes	Board game provides a space for socialisation to occur as players are either set up in pairs or play on their own.
Externalisation	Peer-to-peer dialogue and the creation of shared knowledge	Yes	The game asks the players to plot a route keeping energy and risk in mind. Furthermore, the discussion is sparked using flight updates and comment cards where players are required to answer questions.
Combination	Dissemination of explicit knowledge	Yes	Players discuss how they envisage future flights and their implementation in the real world. During the debriefing phase, the facilitator transforms players' tacit knowledge into more explicit knowledge by debunking their assumptions.
Internalisation	Engage all players using simulation to embody explicit knowledge and facilitate experiential learning	Undetermined	While there was active participation of all players, it is difficult to determine if they adopted the externalised knowledge into their own thinking.

"I mean, I dunno … you couldn't enforce certain routes if people didn't want them over their properties or whatever. That's not something you could enforce really, is it? ***(Female Participant 2, Group 1)***

Well, I would say you, I know it's, it's quicker to go by the [drone], uh, …, but then you are going across people's gardens, et cetera, and you would have to have a lot of people to think that's okay. ***(Female Participant 1, Group 1)***

You will need airspace control … ***(Female Participant 3, Group 1)***

Yeah, airspace control, that's what you would call it. Because you know, as my granddaughter said, you can't have 'em flying over gardens." ***(Female Participant 1, Group 1)***

Comment cards also led to reflections on drone regulation, with player dialogue covering topics such as registration and licensing of drones. Players envisioned beyond the game and reflected on what they thought should be implemented in a real-world setting (Jean et al., 2018a), for example, Group 3 discussed drone registration:

"Well, they're supposed to be registered, aren't they?" ***(Female Participant 4, Group 3)***

"Should they have clear identification cards, so you know which drone you are reporting?" ***(Female Participant 3, Group 3)***

"Registered. So you know which one." ***(Female Participant 1, Group 3)***

This reflects the findings of Wang et al. (2016) who noted participants had higher concerns in private compared to public spaces. A player expressed frustration on their encounter with a drone, causing them anxiety about its use and concerns about licensing given its intrusive and unwarranted presence. Here, Participant 5's concerns related to a drone's capacity to move three-dimensionally giving visual access into accommodation that would normally not be feasible:

"We had someone outside flying one last week. And it was in the dark. No one bothered to stop that individual to find out. First of all, do they have a licence to fly? Why were they flying it? Um, because obviously people, a lot of blocks of flats have curtains, they have blinds, and the blinds are open. So people think when you're higher up … No one's actually going to be looking in? ***(Female Participant 5, Group 1)****"*

The game allowed players to share their personal experiences (tacit knowledge) and knowledge about delivery drones in a 'sheltered environment' where different viewpoints could be discussed, constructed, and negotiated between players that other tools may not allow (see for example, Ampatzidou et al., 2018; Geurts et al., 2007).

3.2.2. Safety and health

During gameplay, players expanded on their concerns about safety, privacy, noise intrusion, illicit drone use and the potential distress that drones may cause, all having health implications. A comment card, '*tell everyone your three main concerns about delivery drones*', specifically, generated responses on concerns.

"… Three main concerns. The privacy. The, uh, accidents, that may or may not happen. And, uh, can anyone pay for them for whatever use they want? There has to be some kind of limit, limited use. … I presume these are, the drones are paid for by customers wanting their delivery quicker … ***(Female Participant 4, Group 3)***

Dialogue on risk led to a discussion about drone collisions and their implications. The examples below demonstrate players reflecting on the safety and risk implications for themselves. They make comparisons to other modes of transport and weigh up whether the risk would be similar.

Group 1 made a comparison to the risk associated with other modes of transport:

"What if two crashed into it? ***(Female Participant 1, Group 1)***

Yeah. But cars crash every day …" ***(Female Participant 2, Group 1)***

Group 2 thought of safety implications for them:

"I hope there is no impact on me with a drone. ***(Male Participant 2, Group 2)***

*Could you elaborate on that? (****Researcher 1, Group 2)***

Well, I hope I don't get hit by one, is what I'm saying. ***(Male Participant 2, Group 2)***

'Cause I didn't even know how big they are." ***(Female Participant 5, Group 2)***

Group 3 further noted that people are more likely to be impacted as delivery drones can, in theory, fly anywhere which links with Pilko et al.'s (2023) research on regulatory considerations about risk and where drones may fly.

"… they are a risk, drones. ***(Female Participant 3, Group 3)***

So there's a lot more people likely to be impacted by it ***(Female Participant 1, Group 3)***

There is, they are a risk to people. ***(Female Participant 4, Group 3)***

Yes. But it's not like an airplane coming down, isn't it? A drone, isn't it? ***(Female Participant 2, Group 3)***

If it hits you. If it … ***(Female Participant 1, Group 3)***

I could get struck by lightning. ***(Female Participant 2, Group 3)***

It depends on the payload, doesn't it?" ***(Female Participant 4, Group 3)***

When it comes to what drones may transport, players were more willing to compromise on risk if drones are only used for emergency or medical deliveries, aligning with earlier studies where drone use was considered most acceptable where there is a 'serious social benefit' (Boucher, 2016, pp.1403). Comment cards stating *'Drones should only deliver items like.', 'Delivery drones should only be used for' and 'delivery drones should be able to deliver food for me.'* sparked a discussion between players in each group.

Group 3 thought of medical use for drone delivery:

" …. So what's the safest thing to deliver? ***(Female Participant 4, Group 3)***

Non-hazard. Not anything hazardous. ***(Female Participant 5, Group 3)***

Non-hazard, non-medical. ***(Female Participant 2, Group 3)***

Not non-medical, but non-hazard." ***(Female Participant 5, Group 3)***

Similarly, Group 1 while thinking of the medical use case reflected on a scenario in which they would use a delivery drone:

"Uh, maybe if I was poorly or, and I couldn't get out. Yeah. ***(Female Participant 1, Group 1)***

Yeah. So in an emergency situation ***(Female Participant 2, Group 1)***

Yes. ***(Female Participant 1, Group 1)***

Yeah, I would like medication … that's important. ***(Female Participant 3, Group 1)***

Conversations among players also lead them to express their distress and annoyance with drone noise being too disruptive with the potential to affect their mental health.

"That could be, though, because of … Enjoying my quiet walks, going to the end of Boscombe Pier, and then all you get is (makes drone sound) oh, I came here for peace and quiet" ***(Female Participant 5, Group 3)***

"Do you think some people then might find it very distressing? Might be frightened, or it might affect their mental health? ***(Female Participant 1, Group 3)***

3.2.3. Assumptions about drones

A common misconception was that drones would reduce traffic congestion.

"Would take a lot of cars off the road." ***(Female Participant 2, Group 3)***

"… and they reduce traffic, they reduce one of a motorbike." ***(Female Participant 4, Group 1).***

Darvishpoor et al. (2020) argue that this is unlikely as 'delivery drones have limited endurance and cargo capacity.' Additionally, Karlı and Tanyaş (2024) recognised that drones serve well for last-mile deliveries for lightweight and small parcels therefore researchers are exploring multi-mode transport methods such as drones and van or truck delivery (see e.g. Pachayappan, 2023; Wang et al., 2021). This is unlikely as last-mile delivery drones only have the capacity to carry small items and vans will continue to deliver most packages (Darvishpoor et al., 2020).

Players were drawn towards medical use cases when stating preferences for delivery types as they thought it would be more efficient than road transport.

Medicines, I think, would be the most important. Get them there quicker than the road. ***(Female Participant 5, Group 3)***

Oakey et al. (2022) and Smith et al. (2023) argue that while there is scope for time savings using drones, most medical items are routine and there would be no advantage from a faster delivery.

3.3. Reflections on the value of the board game

3.3.1. Value for researchers and policy

Games have been used in the policymaking process for decades (see for example, Duke, 1995, 2000; Mayer, 2009). Guerts et al.

(2007 p. 546) suggest that games can facilitate effective dialogue across diverse groups, encouraging the sharing of ideas and bridging knowledge gaps indicated in the findings of this board game (Geurts et al., 2007). As demonstrated in the sections above, the gameplay engaged players with identifying routes across a place they know on the map, while encouraging them to raise issues and discuss these with others, increasing the accessibility of the game, which is important for a one-off involvement activity. Players were keen on finding out more and listening to each other's views contributing to tacit knowledge. They posed queries to researchers who in turn exposed them to explicit knowledge during the debriefing session; therefore, the game demonstrated knowledge co-creation and social learning. Furthermore, respondents were drawn to land on hexagons marked with a comment card, for example, "*I'm moving to a speech bubble.*" ***(Female Participant 3, Group 1).*** This study, therefore, demonstrates the value of a board game as a tool to encourage the expression of diverse views and to support critical thinking whilst players explore complex concepts. Players also recognised that the game was successful in encouraging discussion, with one stating "*… it certainly has triggered a lot of conversation!*" ***(Female Participant 1, Group 3).*** As such, the game would be a useful tool to use at the start of deliberative research involving multiple sessions as it helps build rapport between participants. The sample size for this initial study was small, skewed to older people and dominated by a female demographic. Further work will reach a more heterogeneous sample and, as one participant noted, *"… it would be interesting if we'*d *been a mix of the ages, men and age."* ***(Female Participant 1, Group 3).***

The findings of this study reflect the nascent views of an audience with little or no exposure to delivery drones, and there are several important considerations for policymakers when it comes to forming future regulations. Players were unanimous in the view that drone flight paths, landing and take-off sites need to be further away from private spaces as they could be intrusive. Players also expressed their concerns about the impact of drone noise on their mental health and questioned their safety in terms of drone risk and collisions. The discussions emphasised the need to issue licences and registration for the identification of drones to indicate the delivery purpose which would ease participants' concerns. Findings also demonstrate that the public lack knowledge and experience with drones, though they are interested in learning more about the operational parameters and would like to see more trials and provision of information to the public. The gameplay therefore represents an initial step to involve audiences with the concept of delivery drones. There is more work needed to help participants develop a nuanced understanding of delivery drones. This includes providing more background information and addressing pre-conceived views as suggested by Blastland et al. (2020). There is more work to be done to enable participants to develop a nuanced understanding of delivery drones with work needed to provide more background information and some pre-bunking (see for e.g., Blastland et al., 2020) of pre-conceived views.

3.3.2. Value for participants

The game proved to be a useful tool to involve a general audience who would in most circumstances be removed from the policy planning process, even though delivery drones could directly impact people. It allowed participants the opportunity to break away from their daily lives and explore other perspectives and viewpoints which were shared, constructed, and negotiated collectively. The value of the board game for players lies in understanding complex scenarios, triggering discussion about a topic they would otherwise not discuss, and providing a space for them to reflect (see for e.g., Gee 2005; Crookall 2010; Ampatzidou et al., 2018; Jean et al., 2018a). This finding is in line with academics such as Ampatzidou et al. (2018), who acknowledge that the value of a board game lies in triggering discussions about topics that would not be otherwise discussed. Additionally, it aligns with researchers such as Gee (2005) and Crookall (2010), who demonstrate that the value of a game lies in learning and understanding complex scenarios, while Jean et al. (2018a) illustrate that games provide a space for reflection. These factors have been evidenced in the findings of this research, along with the use of a game to help foster relationships between players and allow for the stages of knowledge co-creation to take place.

3.3.3. Next steps

There is a need for future work to address participant assumptions and misconceptions. Game sessions in future will include a short video based on Blastland et al.'s (2020) pre-bunking suggestions (Blastland et al., 2020) to address misconceptions and to clarify the concept of risk. Addressing these misconceptions before playing the board game will help gather more informed views.

The positive outcome of participant interaction with the board game has led to further development, with this initial version acting as a template that can be applied to other locations for use by other researchers and practitioners. The game can be tailored to other places, including place-specific issues in flight update cards. Participants from this study offered suggestions to develop the game including improving competitiveness amongst players, introduction of more hazards and improvements to game mechanics related to risk. The board game is currently being developed for the Solent region of the UK for use with specific stakeholder groups.

4. Conclusion

This paper reports on the development of a board game to explore transport futures and initial study findings. The objective of the game was to generate and facilitate discussion with the results indicating the usefulness of this method. The study demonstrated the benefits of using a serious game as a tool for the participatory process by: (i) exploring and testing complex concepts such as route, risk, and energy use of delivery drones; (ii) evoking knowledge co-creation, social learning, and reflection; and (iii) making the participatory process feel pleasant and easier to attend in a collaborative setting.

The board game was able to demonstrate difficult concepts of risk, energy, and route choice to non-experts, encouraging dialogue and reflection about a range of delivery drone issues with implications for health through infringement of privacy, annoyance and safety concerns. Participants were also more supportive of drones used within the health sector, as opposed to other industries. Participants reported having a positive experience for example one participant said "I thought this was fun! Apart from all the bad cards we got! It was fun, I enjoyed it!" (*Male Participant 2, Group 2)* and another said "The game was very good … and it made you sort

of think about how much energy we used. Like, that was amazing to me." (*Female Participant 3, Group 1)*.

The potential of this board game lies in its adaptability and contextualisation to different locations; therefore, it can be used by other researchers and policymakers in forming future legislation and transport planning for delivery drones. Ampatzidou et al. (2018 p.35) indicate that such tools have been regarded as useful in overcoming barriers to public involvement, making the process enjoyable.

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CRediT authorship contribution statement

Taalia Nadeem: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Janet E. Dickinson:** Writing – review & editing, Supervision. **Angela Smith:** Writing – review & editing, Methodology. **Katherine King:** Writing – review & editing, Methodology. **Tom Cherrett:** Funding acquisition. **Andrew Oakey:** Writing – review & editing. **Matt Grote:** Writing – review & editing. **Aliaksei Pilko:** Writing – review & editing, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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