Sustainable Sip: Learning Concepts Of Business Sustainability Through A Hybrid Game

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Abstract: We present *Sustainable Sip*, a hybrid multiplayer round-based game designed to provide an experiential learning environment for university-level students at the University of Queensland, Australia. It aims to facilitate literacy around the fundamental concepts of business sustainability, specifically the tensions and interplay between economics and sustainability, and systems thinking. This paper represents stage 1 of this project (design, development, testing). Impact assessment will be covered by stage 2 (application), which is outside the scope of this paper. Each player manages a coffee shop in a competitive market, seeking to maximise their customer base, whilst minimising the production of waste (unsold coffee tokens). Each round, players must decide how much coffee (inventory) to buy from the wholesaler, and the price to sell coffee to customers. Players aim to balance the dimensions of economic performance, environmental sustainability, and customer loyalty; the player that best achieves this wins the 'Sustainable Sipper' award. 'Customer loyalty' is a central concept, calculated in the app for each player and is influenced by the shop's coffee price, quantity of waste the shop produces, and a player's ability to meet customer demand. The game design explicitly draws from system thinking, user-centred and hybrid design, and from self-determination theory (motivation). *Sustainable Sip* has undergone early testing with preliminary feedback highlighting that the gameplay is simple, intuitive and interactive, aspects that are attributable in part to the game design and the hybrid approach.

Keywords: Sustainability Literacy, Coffee Shop, Hybrid Game, Systems Thinking

1. Introduction

Sustainable Sip is a round-based hybrid serious game designed to provide a motivating environment for end-users to learn fundamental concepts of business sustainability and systems thinking. Serious games are known to facilitate knowledge acquisition through active modes of learning (Madani et al., 2017). A pedagogical shift towards active learning is facilitated by the demand for a more activity-based learning environment (Arias-Calderón et al., 2022), increased prevalence of social media (Bohyun, 2015), ubiquity of computers in the classroom (Southgate et al., 2017), widespread popularity of videogames (Morikawa, 2023), and the emergence of "digital natives" with high expectations about teaching models that use digital technology (Jukes et al., 2010).

The aim of *Sustainable Sip* is to provide an experiential and dynamic mechanism for teaching concepts of sustainability and systems thinking using two learning objectives. The first learning objective is to teach tertiary-level students about core concepts of systems thinking (Sterman, 2000), specifically, how system behaviour is informed by system structure (Sterman's 'dynamic hypothesis'). The second objective is teaching tertiary-level students about the social, ecological and economic dimensions of business sustainability. In this paper, we focus on the design of *Sustainable Sip* that draws upon these two learning objectives, and upon the construct of 'motivation'. This paper does not cover testing the impact of the game (ability to meet learning objectives) – this will be the focus of later research.

2. Design Framework

The design of a serious game typically focuses on promoting active participation and interaction (Pappa and Pannese, 2010) whilst balancing educational content and entertainment elements (Aydin et al., 2022). There is numerous literature on game design (e.g. Pappa and Pannese, 2010; Killick 2022), making the process somewhat challenging (Söbke and Streicher, 2016), although design often includes standard elements e.g. mechanics, story, game flow, aesthetics and technology (Killick, 2022). Having clear learning objectives is also important for serious games (Redhead and Saunders, 2019). To guide the design of *Sustainable Sip*, we employed the framework presented in Figure 1, which scaffolds the core considerations of the process in a manner that is similar to Crotty's (1998) research design framework.

2.1 Design Focus

The foundation of designing *Sustainable Sip* is provided by the learning objectives that the game aims to address. Having clear learning objectives is considered critical for gamification design (Redhead and Saunders, 2019). The

learning objectives used for *Sustainable Sip* are teaching tertiary-level students about core concepts of systems thinking, and about the social, ecological and economic dimensions of business sustainability.

2.2 Theoretical Framework

Self-determination theory (SDT) and the intrinsic factors of motivation (Ryan and Deci, 2020) is used as the theoretical framework. SDT has been one of the most applied theoretical frameworks to serious games (Krath et al., 2021), especially with focus on the intrinsic factors that influence end-user motivation to play these 'games'. These intrinsic factors (autonomy, relatedness, and competence) are valued as having the greatest outcomes for learning (Ryan and Deci, 2020).

2.3 Design Framework

The design framework for *Sustainable Sip* is based on user-centred (Caroux et al 2015) and hybrid game (Kankainen and Paavilainen 2019) design. The user-centred approach is focused on constructs of engagement, enjoyment and perception, and has overlap with intrinsic motivation (Caroux et al. 2015).

2.3.1 Hybrid Game Framework

A hybrid game framework comprising of an analogue boardgame and digital application (app) is used to harness the tactile feel of a boardgame whilst enabling complex algorithms to be integrated quickly and accurately by the digital component. The analogue component inherently facilitates a multiplayer game environment, linking it to intrinsic motivation and user-centred design (e.g. Song et al., 2013). Analogue boardgames, also known as "tabletop" games (Kosa and Spronck, 2018), provide physical interaction that has been shown to help with communication (Illingworth and Wake, 2019), motivation (Kosa and Spronck, 2018), and provide an engaging experience to users (Lean et al., 2018). The ability of players to interact with tactile objects was seen as an important component for the game framed around learning in the classroom. Augmenting this physical component with technology, such as using computer simulations, can increase their ease of use by automating mundane repetitive tasks (Kosa and Spronck, 2018; Kankainen and Paavilainen, 2019). More importantly for *Sustainable Sip*, augmenting a tabletop game with a digital app provides three key attributes: (1) it provides a reliable and rapid means of quantifying the potentially complex interactions between social, ecological and economic dimensions, (2) data can be presented back to players (e.g. on a large screen) in real-time via a dashboard, and (3) data generated from the gameplay can be stored and retrieved for later analysis.

Kosa, M. and Spronck, P. 2018. What Tabletop Players Think About Augmented Tabletop Games: A Content Analysis. In Proceedings of the 13th International Conference on the Foundations of Digital Games, 6:1–6:8. FDG '18. New York, NY, USA: ACM, 2018

2.4 Design Methods

Systems thinking (Sterman, 2000) is used for conceptualising the game engine for *Sustainable Sip* as it provides a formal framework for constructing and quantifying the components of a complex transdisciplinary system. It is especially salient for *Sustainable Sip*, which bridges social (customer loyalty), economic (supply-demand-price dynamics), and environmental (waste) dimensions whilst systems thinking is aligned with one of the learning objectives.

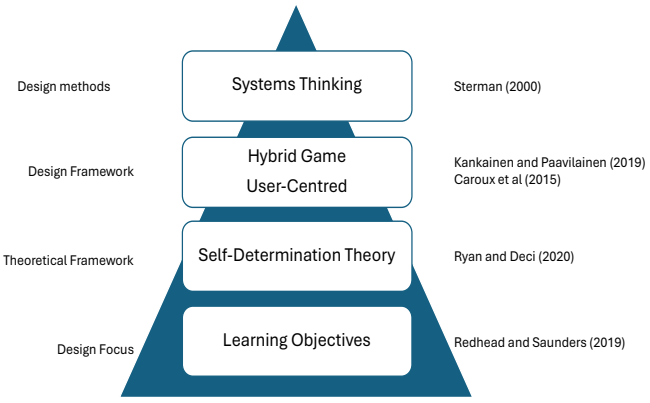

Figure 1: The design framework used to develop Sustainable Sip

3. Design Features

To provide scope for the design process, we developed the following design principles. These were established by the authors through an iterative approach, framed around the four levels of the design framework.

3.1 Principle 1 - Simplified Gameplay

An early decision in the design process was that the gameplay had to be as simple and unambiguous as possible. The rationale was that this approach would help to keep instructions simple to minimise time spent learning rules (Møller and Hansen, 2016), an important cognitive consideration when using the game in the classroom (Catalano et al., 2014).

Sustainable Sip has been purposefully designed to have only a small number of player decisions so that the game should be easy to learn and play, and not be inhibited by a large number of rules around decision-making. The required decisions for all players are:

1. *Decision 1 - How many coffee tokens to purchase from wholesaler?*
2. *Decision 2 - What price to sell the coffee?*

To help simplify these two decisions further, the number of coffee tokens that a player can purchase is restricted to the range 1 – 20 (Decision 1) and the price they can sell is restricted to either $1, $2, $3, $4, $5, $6, $7, $8, or $9 (Decision 2).

Sustainable Sip also includes a moderating role (Game Master) who leads the players through the gameplay whilst also managing the transactions associated with the two decisions. The rationale is this role minimises the transactional costs of players learning the rules upfront i.e. the Game Master teaches the players as the game unfolds, situating the learning as a facilitated workshop approach (Catalano et al., 2014).

The app assists with players understanding of the game by providing a roadmap for gameplay, using a bulletin board that periodically provides instructions to the players and through guidance provided by the Game Master (Figure 2). By default, these bulletin board instructions are only shown during the first round (round 1) of gameplay (but this can be toggled to show every round).

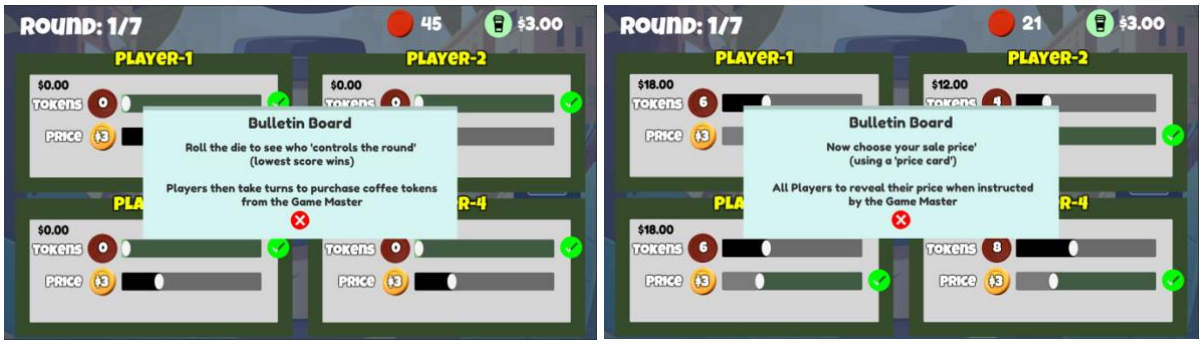

Figure 2: Bulletin board messages are used in *Sustainable Sip* to direct gameplay

The user interface (UI) of the app has been designed to help simplify the game play. The Game Master enters the player decisions into the app through 'sliders' (Figure 3). At the start of a round, the token sliders are first activated and the price sliders are deactivated. Once all the token data has been entered, the token sliders become deactivated and the price sliders are activated. This process helps ensure that all data for Decision 1 has been entered before Decision 2 is made. All activated sliders are colour coded to indicated whether the data has been locked in (black sliders) or not. For the token sliders, these will be green if they are not locked in. For the price sliders, the colour depends on whether the slider is above (green), equal (grey) or below (red) the wholesale price. The numerical values of each slider is shown to the left of the slider, providing additional feedback to the Game Master and the players.

Finally, the app manages complex calculations that account for the dynamics of supply-demand-price elasticity, along with the calculation of customer loyalty (see Principle 6). A 'black box' approach was taken so that the precise nature of these is not known to the players (Principle 4 – uncertainty) but also enables the game to include complex dynamics without burdening the players with these details.

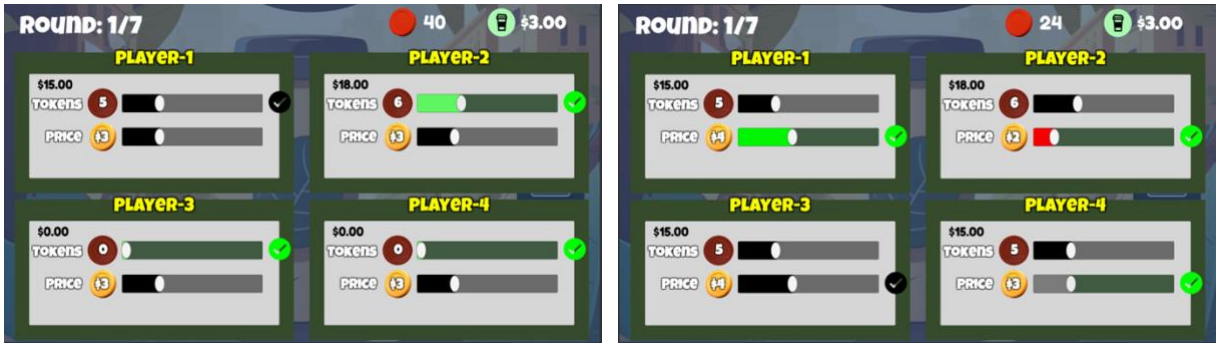

Figure 3: Sliders used to enter data in the app. Left panel – shows tokens purchased by each of the four players being entered. Right panel – shows price setting for each player

3.2 Principle 2 - Story Telling

It was important that the game had a strong story telling element. The compelling nature of a good story has been linked to motivation (Alexiou et al. 2022) and user experience (Caroux et al. 2015), and is an important component of systems science (Sterman, 2000). The story telling is presented within the app, through the use of disruption cards (Principle 4), and via the Game Master's interaction with the players. Beyond managing the business exchanges with players (selling tokens) and entering the 'decision' data into the app, the Game Master is responsible for 'setting the scene'. At the start, the Game Master introduces *Sustainable Sip* to the players by displaying a story that encapsulates the context ("*Welcome to Sustainable Sip, a game that provides a dynamic and experiential way to learn about the core concepts of business sustainability*"), instructions ("*Each round you will need to decide how many cups of coffee you pre-purchase…*"), and game objective ("*The Player that best balances profit and waste will be declared 'The Sustainable Sipper'*"). This story is presented across 11 'pages' in the app (e.g. Figure 4), with each page containing a short statement about an aspect of the game (context, instruction, or objective) along with an associated graphic. We purposively use short statements and clear graphics so that the narrative is introduced in bite-sized chunks.

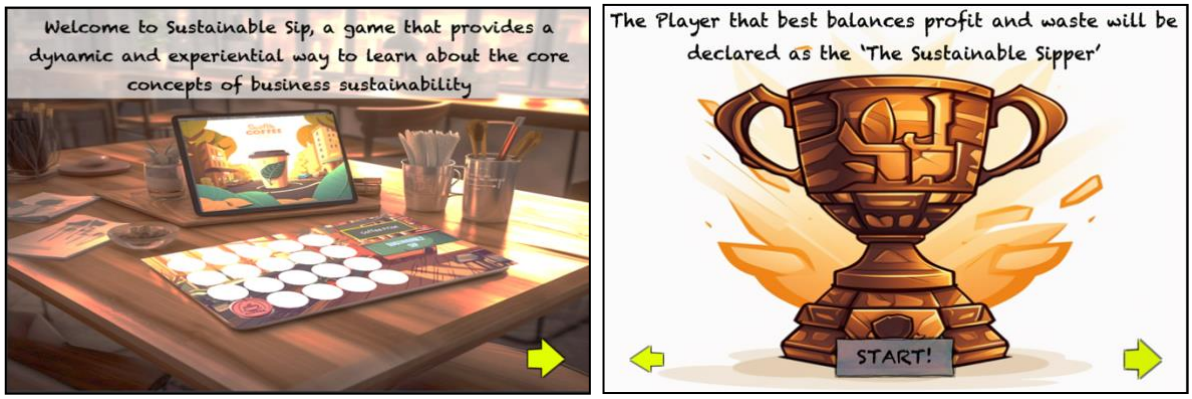

Figure 4: Left panel - The first page of *Sustainable Sip*'s story that appears after pressing the start button on the menu page. Right panel – page of the story that highlights the Sustainable Sipper prize.

3.3 Principle 3 – Prize Focus

Sustainable Sip was designed with the intention of providing a clear objective for 'winning the game' using the "Sustainable Sipper" prize (Figure 4 – right panel). Including such prizes have been shown to contribute to knowledge acquisition (Whittaker et al., 2021) and impact on motivation (Johnson et al., 2018). However, prizes may diminish feelings of autonomy (Deci et al., 1999) e.g. through presenting a controlling factor. It was desired that players be rewarded for their cumulative performance, which aligns with the sustainability theme of this game (and the second learning objectives), which by definition is centred on long-term performance. Information on progress towards this prize is presented in an information panel at the end of each round (Figure 5 – left panel). Detail about the loyalty factors can also be shown (Figure 5 – right panel) to highlight how waste, supply, and price are influencing customer loyalty ratings. This aligns with the first learning objective in terms of enabling the players a more systemic insight into their performance.

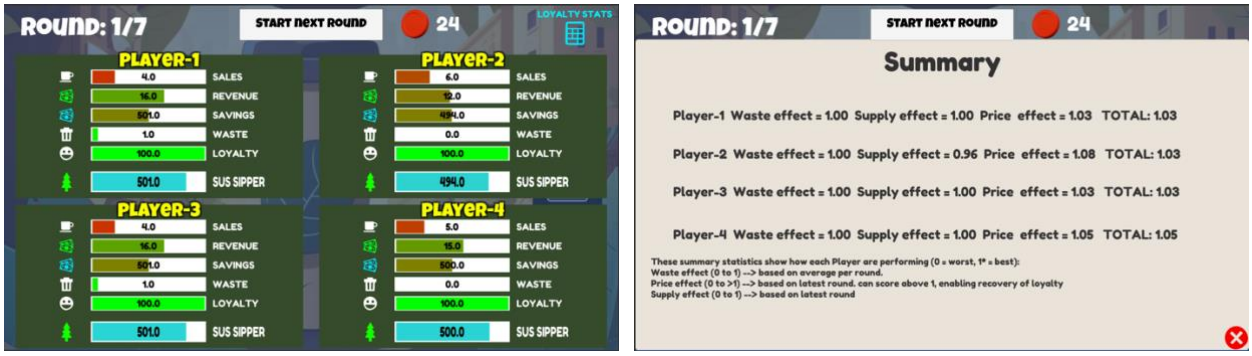

Figure 5: Left panel - 'Leaderboard' styled information presented to players at the end of each round. Right panel – additional information on the loyalty statistics that can be used for more in-depth discussion of player performance.

3.4 Principle 4 - Uncertainty in Decision-making

This design principle was motivated by the desire that any decision-making in the game involve uncertainty.

3.4.1 Multiplayer Game

Uncertainty in player decision-making is inherently incorporated in *Sustainable Sip* because it is a multiplayer game. *Sustainable Sip* accommodates four players (or four teams of players), each in control of a coffee shop. Each player (or team of players) aims to balance the dimensions of economic performance, environmental sustainability, and customer loyalty; the player that best achieves this wins the 'Sustainable Sipper' award (Principle 3 – prize focus). Information on how each player is progressing is summarised in a leaderboard styled dashboard in the app (Figure 5) that shows the key economic (sales, revenue, savings), environmental (waste) and social (loyalty) indicators as health bars. Using a multiplayer game can help players can engage in social learning (Ross and Weaver, 2012), and introduce "social competition" that can facilitate enjoyment (Vorder et al., 2003) and increase intrinsic motivation (Song et al. 2013).

A player's strategy has been shown to be affected by the uncertainty of an opponent's strategy (Calford, 2020). Players are competing against each other, and strategies are being based in the absence of *a priori* knowledge of what the other players will do. This is especially the case for price setting (Decision 2), where players reveal their prices simultaneously (see Principle 5). Conversely, the purchase of coffee tokens (Decision 1) is turn-based as determined by the player that controls the round (see Principle 5), and therefore the player that goes last has the benefit of knowing the purchases made by the other players.

3.4.2 Dynamic Uncertainty

Uncertainty is also integrated in the game through the hidden (black box) calculations of supply-demand-price-waste-loyalty dynamics that are calculated in the app. The underlying algorithms used to calculate the customer choice for a player's coffee shop (i.e. customer share) is not known by the players. Rather, a player's knowledge of these dynamics is articulated through the 'story' delivered at the start of the game, by the status of a player's 'health bars' indicating their performance so far (Figure 4), and the disruption cards that provide an indication of how the 'mood' of customers has changed around waste and price. Therefore, the purchase of tokens (Decision 1) is undertaken without precisely knowing the customer demand – buying too much coffee will cause a problem due to waste (unsold coffee tokens) but buying too little runs the risk of undersupplying demand. Both risks have implications for customer 'loyalty', but these are not weighted equally e.g. undersupply might have bigger effect than waste on reducing loyalty, but waste might have bigger effect than supply-demand on recovering loyalty.

3.4.3 Disruption Cards

Disruption cards are an additional source of uncertainty in *Sustainable Sip*. The aim of disruption cards is to introduce a change to the game dynamics through the following:

- Wholesale Price: adjusts the cost of purchasing coffee tokens from the Game Master
- Price Factor: changes the influence of price on Customer loyalty

- Waste Factor: changes the influence of waste on Customer loyalty

A single disruption card only affects wholesale price, price factor or waste factor. Waste factor can only increase, a constraint motivated by the desire for a game arc where customer sentiment will only increase towards better waste management practices. Conversely, wholesale price and price factor can both increase or decrease, based on the assumption that these can have a synergistic (price decreases) or antagonistic (price increases) relationship with the waste factor. Disruption cards are managed by the app, appearing irregularly as a spinning newspaper at the start of a round (Figure 6). This animation reveals a disruption panel that has three sub-panels (Waste Factor; Price Factor; Wholesale Price). A physical disruption card is selected by the game master, which will change one of these three categories.

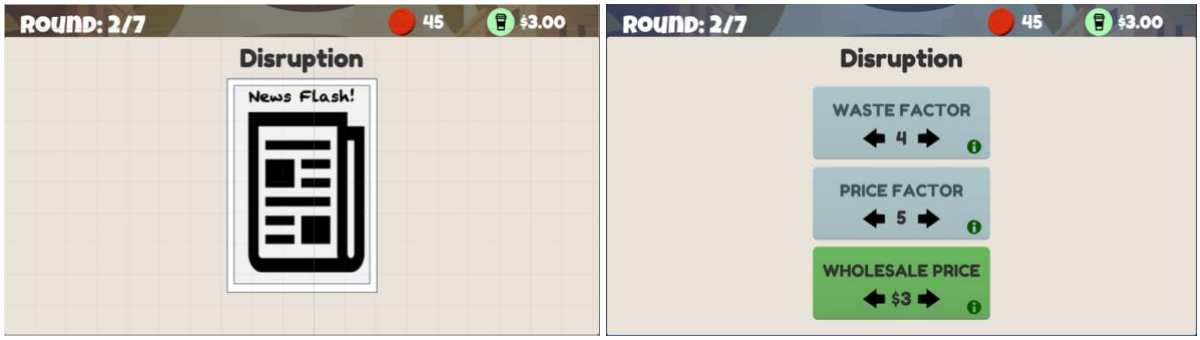

Figure 6: Disruption UI panel as displayed in the app. The occurrence of a disruption is indicated by the appearance of the disruption UI panel along with a spinning newspaper (top-left). This spinning newspaper is then replaced by three UI categories for waste, price and wholesale price (top-right).

3.5 Principle 5 - Round-based Gameplay

Sustainable Sip was specifically designed to be a round-based game based on the desire to provide players with the opportunity to revise their strategies routinely throughout the gameplay. As the app presents feedback information at the end of each round (Figure 4), the players can use this updated knowledge to inform the next round of decision-making.

3.5.1 Simultaneous Versus Turn-based Decision-making

A challenge of using a round-based approach is deciding whether players should make their decisions simultaneously or turn-based. A conceived advantage of simultaneous decisions is that this introduces a 'prisoner's dilemma' (Amadae, 2016) type of uncertainty into the decision process (incorporating an opponent's potential action into your own decision). A conceived disadvantage is the difficulty in integrating this process into a hybrid game. This is especially pertinent for Decision 1 (*How many coffee tokens to purchase from wholesaler*), where purchasing tokens requires a physical transaction between each player and the Game Master.

3.5.2 Controlling the Round

A turn-based approach overcomes the integration problem but presents the challenge that a player going first has less information about the 'system' than following players, providing an advantage to the latter. To address this issue, we introduced the concept of 'controlling the round'. This works by having one player determine the sequence that players purchase their tokens from the Game Master (Decision 1) for a given round. The 'round controller' is determined at the start of a round by each player rolling a die and applying a 'lowest roll wins' approach. If more than one player rolls the same lowest number (e.g. two players roll a '1') then a tie-breaker is used until there is a clear winner. Once the round controller is established, they announce the sequence that the players will purchase their tokens from the Game Master. Under these conditions, the round controller should select themselves to go last in this sequence so that they will know the decisions of all the other players before they make theirs. To provide a counter point, the pool of tokens is limited so that a player purchasing their tokens last risks missing out on tokens.

3.5.3 Simultaneous Price Setting

For Decision 2 (*What price to sell the coffee*), this integration process was less challenging because there is no physical transaction between players and the game master. To facilitate this, the price options were limited to a small set of price cards: $1, $2, $3, $4, $5, $6, $7, $8, and $9.

Table 1: Tabulated design principles for hybrid game drawn from intrinsic factors of motivation, self-determination theory (Ryan et al., 2006; Farrell & Moffat, 2014).

Factor	Query	Game Features and Rationale
Autonomy *Sense of willingness to play (volition)*	Does the game present a player with choices?	At the start of a game, each player can choose their 'playing' name to enter into the App. The use of a 'round controller', who selects the sequence of players (Decision 1).
	Does the game provide rewards for players?	Sustainable Sipper prize for the overall winner.
	Does the game include non-controlling instructions?	There is minimal scope for non-controlling instructions as the gameplay is moderated by the Game Master. This is a trade-off for simplified game play and the use of a prize as the key focus.
Relatedness *Role within a social community*	How does the game foster feelings of being connected to others?	The game helps present player-specific imperfect information about the game state. The role of 'round controller' fosters connections.
Competence *Need for a challenge and feeling of effectance*	How does the game provide opportunities to learn new skills?	Players are required to make decisions under uncertainty. The game provides student-centred learning around market dynamics by placing players as a manager of a business. Disruption cards provide indicators to the players about shift in market conditions and incrementally change game dynamics.
	How does the game provide positive feedback (including readily mastering tasks of the game) to players?	The game has six core measures of competence that provide feedback (savings, revenue, sales, loyalty, waste, sustainable sipper score).
	How does the game help players to master controls / combinations (perceived competence)?	The game is intentionally designed with simple gameplay that can be easily mastered (positive feedback) rather than being a barrier (negative feedback).
	Are there Opportunities in the game to unlock new abilities?	The game does not include opportunities to unlock new abilities.
Presence	Does the game make use of intuitive controls that make sense, are easily mastered, and do not interfere with sense of being in the game?	The number of decisions that a player has to make is intentionally small (2) and constrained to a small number of options. The app hides complicated calculations to make game easier to play and less likely for mistakes to occur.
	Does the game create a compelling storyline for the user?	The game comes with a story (narrative) that is provided for the game. The use of Disruption cards is aimed at changing the narrative during gameplay.

3.6 Principle 6 – Use of Simulation Modelling

A simulation modelling approach, grounded in systems thinking (Sterman, 2000) was used to guide the mechanics utilised by the app i.e. calculation of supply-demand, player costs and revenue, and customer loyalty. The motivation was to have these factors as deterministic rather than probabilistic events (economic outcomes heavily influenced by the roll of a die e.g. 'monopoly'). This principle has overlap with Principles 1 (simplified gameplay) and 4 (uncertainty). The specific technical details of this modelling is beyond the scope of this paper. Briefly, simulation modelling occurs each time the player decisions have been entered into the app. Customer share for each player is first calculated based on the player retail prices (Decision 2). This is then modified based on the carry-over loyalty rating from the previous round and modified further for a price-demand effect. The loyalty rating is then updated for the effects of price, waste, and supply. Both the price effect and waste effect on loyalty are calculated using a threshold that demarcates when customers are happy, or unhappy, with the price/waste. Whilst the price effect is calculated on the current round, 'average' waste (over all rounds played thus far) is used. The effect of supply is calculated using a sigmoid function so that it is bounded at upper and lower levels.

4. Game Design Summary

Table 1 summarises the design features used in *Sustainable Sip* that align with the intrinsic factors of motivation (Table 1). Most focus has been on aligning the intrinsic factors with gameplay simplicity (Principle 1) and reward (Principle 3), although the latter potentially comes at the cost of autonomy. *Sustainable Sip* does present a player with choices (Decision 1, 2) and rewards, which are lines of query for autonomy (Table 1). However, there is an absence of non-controlling instructions, which can diminish sense of autonomy (Deci et al., 1999). This is a result of the greater priority placed by the authors on the simplicity of game play and the prominence placed on the Sustainable Sipper prize.

4.1 Game Testing

4.1.1 Educator

The overarching role of the educator (teacher, lecturer, tutor) is to introduce *Sustainable Sip*, providing general context for the game (business sustainability), providing a broad outline of gameplay ("you will be managing a coffee shop") and objective ("to balance revenue with sustainability"), communicated through a presentation slides. An educator may take on the role of the Game Master, leading the players through the gameplay and managing any transactions. At the end of the game, the educator leads a class discussion about how the game went, what strategies were used, and what learnings were made. Any questionnaires are then provided to each participant to provide individual-level information.

4.1.2 Beta Testing

Sustainable Sip has undergone preliminary testing with academics and professional staff at the University of Queensland, Australia. This testing was undertaken to provide early feedback on the game's design and gameplay. Testing of the game occurred in March, 2024 in a class at the University of Queensland. The class (n=77) was separated into eight tables, with each table playing *Sustainable Sip.* Each table was provided with a game kit consisting of a six-sided die, four playing boards, 45 coffee tokens, a 1 A4 page set of game instructions, and a USB containing the app (PC and Mac OS versions). One person was selected by the players at each table to be the Game Master and installed the app onto a laptop computer. A short presentation was given by the educator at the start to outline the game's rules, aim and process. This presentation also included a short demonstration of the game using the app. The 8 games were overseen by three educators. At the end of the game (approx. 60 minutes), there was a class-level discussion reflecting on the game. An anonymous questionnaire was provided to students (n=39 responses) asking (1) what aspects of the game did they enjoy? and (2) what could be done to improve the game?

Overall, feedback highlighted that the gameplay is simple, intuitive and interactive, aspects that are attributable in part to the game design and the hybrid approach. The use of a Game Master, an app, and the use of simple gameplay rules, appears to help players quickly learn how to play the game. In addition, the app provided a focus and discussion point for the players at the end of each round when the results were shown (i.e. Figure 4), especially if these were shown on a large screen (common in teaching rooms at the University of Queensland). Suggested changes by the testers included reducing some of the physical components (adopted – initial version used physical money to represent player savings, which did not add to the game experience), refining the story (adopted), and adding music (not adopted). It was also suggested that the number of awards be changed; early design of *Sustainable Sip* featured four awards to reward different dimensions of the game (economic, environmental). However, feedback highlighted that better gameplay (and narrative) was achieved by just using the Sustainable Sipper prize. In addition to feedback on the game, the authors have picked up on how players have used the game in their strategies. For example, this highlighted that Decision 1 can give (but not always) an insight into each player's strategy for pricing. For example, players who purchased a low number of tokens (< 4) might implement a 'high-price, low-volume' strategy, whilst those that purchased a high number of tokens might implement a 'low-price, high-volume' strategy. However, with regards to purchasing a high number of tokens, this was also linked to the strategy of restricting the availability of supply to rival players.

5. Conclusion

We have presented *Sustainable Sip*, a hybrid (gameboard + app), turn-based, multiplayer game that has been designed as fit-for-purpose for students to learn about sustainability from two perspectives: systems thinking and business sustainability. We have explicitly structured our design on a framework that helps to tie the

learning objectives, theoretical and design frameworks, and design method, together. Six design principles were used - whilst all principles were valued by the authors as important, there were instances of trade-offs, especially when viewed through the lens of the intrinsic factors of SDT. Specifically, the desire for simplified gameplay (Principle 1) potentially works against a player feeling that they have freedom of choice within the game (autonomy).

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