

---

## Promoting game flow in the design of a hyper-casual mobile game

---

Andrew Dorokhine

MacEwan University,  
P.O. Box 1796, Edmonton,  
Alberta, T5J 2P2, Canada  
Email: dorokhinea@mymacewan.ca

Sharon Bratt\*

Computer Science Department,  
MacEwan University,  
P.O. Box 1796, Edmonton,  
Alberta, T5J 2P2, Canada  
Email: bratts@macewan.ca  
\*Corresponding author

**Abstract:** This capstone research project described the application and evaluation of elements from the GameFlow model (Sweetser and Wyeth, 2005; Sweetser et al., 2017) to make a hyper-casual tile-matching mobile game more responsive, engaging, and challenging while providing the player with a sense of agency and flow. Mobile game design research, as well as game design from a more general perspective frames the design decisions. Contemporary game design research provided a reference to guide the design decisions. The GameFlow model provided assessment criteria. Results showed that many of the elements of game flow are promoted. Several recommendations emerged, both situational and generalisable, which could enhance the redesign and provide guidance for game designers who use game flow as a core driver. Future research is encouraged to address issues of immersion, social interaction and user interface. Contributions include a new evaluation methodology which combines design science research and action research.

**Keywords:** GameFlow model; mobile game design; engagement; digital design action research; DDAR; software evaluation.

**Reference** to this paper should be made as follows: Dorokhine, A. and Bratt, S. (2022) 'Promoting game flow in the design of a hyper-casual mobile game', *Int. J. Student Project Reporting*, Vol. 1, No. 1, pp.25–42.

**Biographical notes:** Andrew Dorokhine holds a BSc in Computer Science from the MacEwan University in Edmonton, Alberta, Canada. He has a keen interest in game design and working with new technologies, as well as writing. There is nothing he enjoys more than a good story, and he believes that even simple projects can have an interesting story to tell, even if it is just a cautionary tale about developer practices more than an epic fantasy tale.

Sharon Bratt is an Associate Professor at the MacEwan University. Her work as an academic and researcher is motivated by an avid curiosity grounded in research methodologies. Her research exists at the intersection of design, application and evaluation of higher education pedagogies and digital artefacts through a theoretical or an applied lens. Although the devil may be in the details' she enjoys the pursuit as much as the discovery of details themselves. She has 20-year career in academe continues to provide opportunities to engage in the exploration of these spaces and to satisfy her epistemic curiosities.

---

## 1 Background

Sweetser and Wyeth's (2005) GameFlow model is a set of heuristics to guide the promotion of flow in game design. This study *extends* the use of the GameFlow model from a guiding framework to a set of criteria that can be used in design research to assess the experience of flow using digital design action research (DDAR). The primary goal of this research study was to apply concepts of game flow to enhance an existing mobile game. A secondary goal was to continue to bridge the gap between research and design practice through the creation of a new design research methodology. "[G]ood practice increasingly relies on profound research, and that good research always involves particular practices that are not so different from designing" [Joost et al., (2016), p.13]. KoGoNa was developed during an internship as a mechanism for learning the fundamentals of mobile game design and development tools such as GitHub and unity while embedded in a real-world project. The initial design focused on the game's functionality and adherence to coding standards and best practices. The interactive nature of game design prompted the need for enhancements focused on affective concepts such as enjoyment, engagement and challenge while providing the player with a sense of agency and flow.

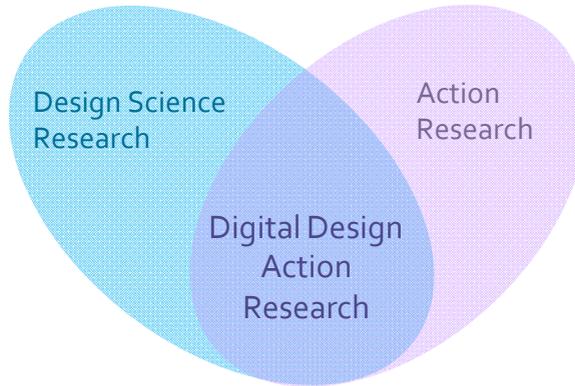
## 2 Methodology

This study proposes a new methodology which combines design science and action research (AR) to assess the efficacy of the enhanced design of a mobile game as shown in Figure 1.

Design science is "knowledge in the form of constructs, techniques and methods, models, and/or well-developed theory ... for creating artifacts that satisfy given sets of functional requirements" [Hevner, (2004), p.4] DSR is the application of design, analysis, reflection, and abstraction for achieving those requirements. According to Hevner et al. (2004, p.80) "[t]he goal of design science research is utility" characterised by a build-evaluate loop with the pragmatic goal of creating or improving a product or practice (Hevner et al., 2004). AR is the "active and deliberate self-involvement of the researcher in the context of his/her investigation" (Mckay and Marshall, 2001). AR, in the context of game design may be viewed as research conducted by the 'designer as researcher' to understand the impact of design decisions to improve some aspect of the gaming experience. To put a finer point on the distinction, design science is a discipline; AR is a methodology. This new methodology, which is proposed here, is *DDAR*. DDAR provides

two novel and unique practices for digital scholarship. First, the practice of the designer-as-researcher who is evaluating a digital artefact for the purpose of improving the product. The second is the object of the investigation which is a digital artefact or product. These two practices combine to create an evaluative, investigative, and analytical research methodology that examines the extent to which a digital artefact has met the specified functional and/or non-functional requirements.

**Figure 1** DDAR methodology at intersection of DSR and AR (see online version for colours)

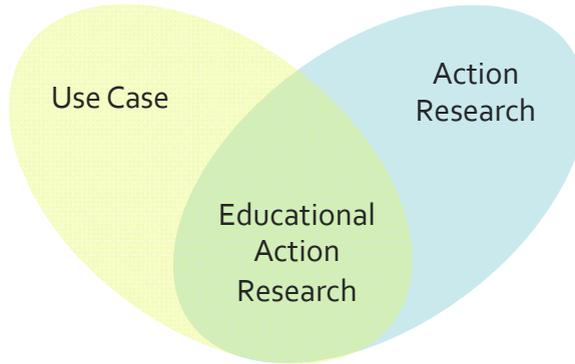


DDRA is the purposeful design of a new methodology. It follows the same evolutionary path of educational action research (EAR), a valid and well-established methodology used in educational research with origins in AR as the name implies. EAR was derived from AR to address a specific purpose and context. It allowed the teacher-as-researcher to investigate an educational artefact (process or product) in which the researcher is inside the context with “tacit knowledge of the situation” (Mckay and Marshall, 2001; Pickard, (2017), p.163]. It may be viewed as the convergence of use case methodology and AR in which the use case is an educational artefact, practice or process as shown in Figure 2. Currently *there is no methodology that combines AR and design science*. DDRA addresses this gap in the evaluation of digital product design within a scholarly context. It was purposefully designed to address two requirements. First, that the designer is also serving in the role of researcher – this is a core feature of AR. And second, the object of the investigation is a digital artefact.

Various forms of AR have evolved since Kurt Lewin’s pioneering work (Lewin, 1946; Adelman, 1993). All derivations of Lewin’s model share a similar cyclical application of problem identification, action planning, implementation, evaluation, and reflection (Kemmis and McTaggart, 1988). A *conditio sine qua* of this process is assessment criteria. Lewin (1946, p.35) observed, “if we have no criteria for evaluating the relation between effort and achievement, there is nothing to prevent us from making the wrong conclusions and to encourage the wrong work habits.” The primary assessment criteria used in this study is the GameFlow model. GameFlow, in of itself, is not a method for assessing game design. It is a conceptual framework consisting of a collection of elements that influence the experience of flow. Therefore, it cannot be used without a methodology. AR, as originally conceived by Kurt Lewin, is a philosophy and methodology. According to Lewin, it is “[t]he research needed for social practice can best be characterised as research for social management or social engineering. It is a type of

action-research, a comparative research on the conditions and effects of various forms of social action, and research leading to social action. Research that produces nothing but books will not suffice” [Lewin, (1946), p.35].

**Figure 2** EAR methodology at intersection of use case methodology and AR (see online version for colours)



Although originally addressing social issues, it is the role of the practitioner, located within the context of the situation, acting as researcher that has led to the adoption of AR by other disciplines – such as education, organisational development, healthcare, and nursing (Moch et al., 2016). The context-independent role of the practitioner-as-researcher provides an opportunity to operationalise a digital-design-centric methodology known as DDAR. This context-specific form of AR will provide a new methodology for researchers in the field of digital scholarship.

### 3 The game

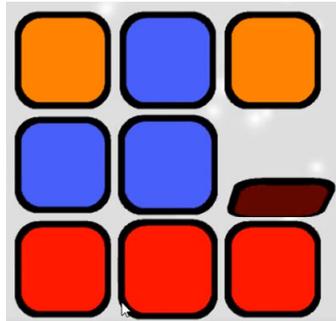
KoGoNa is a hyper-casual, single-player game characterised by short session lengths and simple game mechanics whose goal is to match identical tiles quickly while progressing to a personal best score based on length of time played. The game board consists of a grid of coloured tiles. The goal is to swap two adjacent coloured tiles while the timer gradually ticks down. The player must swipe a tile on the board, causing it to flip onto another tile of the same colour as shown in Figure 2.

Matching the colours will cause the timer to increase, allowing the round to go longer, while a mismatch will immediately end the game. A multiplier increases as the player makes rapid matches and rewards the player with more time per match, and the board can also be randomised to get new tiles if there are no more colour matches available. Randomising the board or taking too long to make another match will reset the multiplier, incentivising the player to match tiles as quickly as possible without making a mistake.

## 4 Mobile game landscape

The mobile app has become a key revenue stream in the digital game industry (Iqbal, 2020). The mobile gaming revenue in North America in 2019 was \$10 billion with a 51% global market share of total gaming revenue (Statista, 2019). The video game genre most often played in the USA in 2019 was the casual single-player as shown in Figure 3.

**Figure 3** Flipping a tile onto an adjacent tile of the same colour (see online version for colours)



The mobile gaming industry is a lucrative yet competitive space. In the third quarter 2019, a total of 29.6 billion mobile games were downloaded globally across both app stores (Statista, 2020). The combined average number of new iOS and Android apps releases per day from the third quarter 2016 to the first quarter 2018 was 7,574. However, not every title becomes a successful, revenue generating product. Freemium, a popular monetisation model in the app ecosystems uses a ‘try before you buy’ experience in hopes that the product is desirable enough to incentivise free users to convert to customers who pay for additional content or features. This is usually in the form of an upgrade or premium membership. Studies suggest that continual mobile game use is strongly driven by enjoyment as determined by design aesthetics, perceived ease of use, and novelty (Merikivi et al., 2017; Catalán et al., 2019; Sepulveda et al., 2019). Other factors which predict high intention to download mobile games include content quality, positive and negative emotions, gender and gameplay time (Pappas et al., 2019).

A core factor behind the success of any game, mobile games included, is *enjoyment*. Enjoyment is a motivator to continue playing games, which is affected by numerous factors, such as challenge, variety, novelty, etc. (Merikivi et al., 2017; Huang et al., 2018). Enjoyment is generally linked to a player’s feelings of flow and the emotions they feel as they play (Caroux et al., 2015). The literature suggests that enjoyment is elicited by challenge and competition, while other research has found a connection between enjoyment and factors such as novelty and ease-of-use (Merikivi et al., 2017) as well as positive emotions during gameplay (Pappas et al., 2019). KoGoNa is classified as a casual game, meaning it has the following core elements:

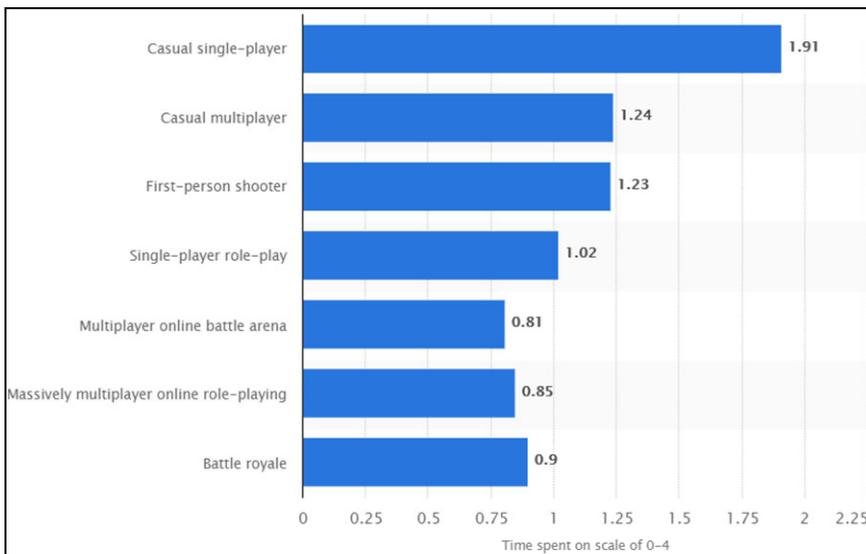
- Rules and goals must be clear.
- Players need to be able to quickly reach proficiency.
- Casual game-play adapts to a player’s life and schedule.
- Game concepts borrow familiar content and themes from life [Trefry, (2010), p.1].

Given the simple, more novelty-driven design that KoGoNa is built on, the designer's goal was to maximise the enjoyment the player feels while playing the game without changing the game's core mechanism.

## 5 Design and interface

Merikivi et al. (2017, p.417) found the system's capacity of regeneration and visually attractive and easy-to-use interface to be the strongest drivers of enjoyment. A vital part of enhancing KoGoNa's game flow into a successful game was to create a more responsive, intuitive, and elegant interface for the user. Ease-of-use and positive emotions are both important factors behind a player's enjoyment of a game (Merikivi et al., 2017; Pappas et al., 2019). The original version of KoGoNa used a muted tile colour palette with lighting which created visual ambiguity between tiles of the same colour. This made it difficult to rapidly and accurately match tiles as shown in Figure 4.

**Figure 4** Leading video game genres played in the USA as of February 2019 (see online version for colours)



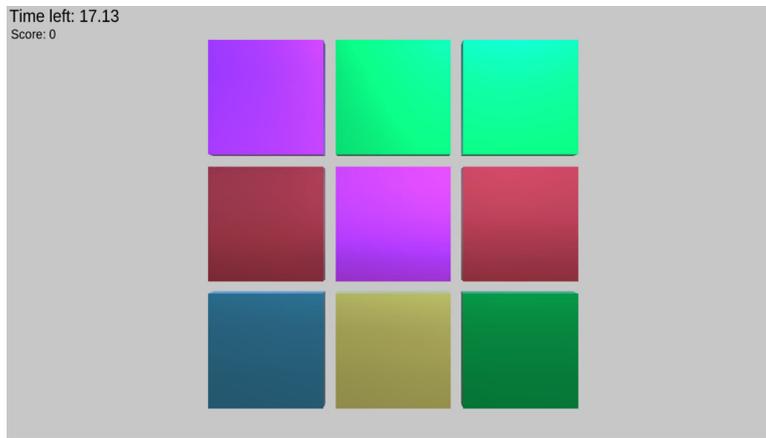
*Source:* Courtesy of Statista

The research on colour and psychological functioning – specifically on colour-emotion associations extends nearly two centuries (von Goethe, 1841) and continues to suggest evidence that hue, saturation, and brightness can stimulate or evoke emotional responses in humans (Adams and Osgood, 1973; Geslin et al., 2016; Wilms and Oberfeld, 2018). The strategic use of hue and saturation can add more emotional appeal to KoGoNa, given the game's premise is to match tiles based on colour. An important goal in colour palette selection is to enhance affect and *player agency*. Player agency is generally understood as player control which Muriel and Crawford (2020) describe as *player as protagonist*;

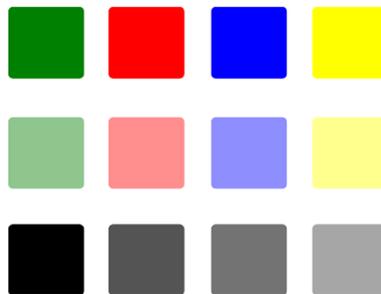
manipulating the flow of events. Delight and excitement motivate the player to persevere while improving their skills at the game (Merikivi et al., 2017). Strategic use of colour includes hue, saturation, and brightness to improve affect. For example, colours with low-saturation or intensity approaching greys or blacks tend to evoke negative emotions such as sadness or fear, while highly saturated colours evoke positive emotions like serenity or joy (Geslin et al., 2016).

Highly saturated colours like bright reds or blues were used to motivate continued gameplay. Conversely, the menu screens and pause screen will use lower-saturation colours such as light greys or more muted hues, to restore a feeling of calm to the player (taking a break from the game) without spoiling the player's positive emotions as shown in Figure 5.

**Figure 5** Visual ambiguity of tile colours (see online version for colours)



**Figure 6** Examples of hues, saturation and tone swatches (see online version for colours)



For example, if the player pauses the game in the middle of a round, the game board can remain visible, but has a translucent grey overlay that mutes the colour saturation while still maintaining generally positive emotions as shown in Figure 6.

When the game continues, a timer can allow the player to get ready again as the overlay disappears, restoring the high saturation of the colours and feelings of excitement to the player as shown in Figure 7.

**Figure 7** Home screen, setting and game over screens in grey tones (see online version for colours)



## 6 Audio elements

Audio, or *game sound* [Collins, (2013), p.25] is another component of engagement and affect. Collins argues that our senses operate in ‘synesthetic unity’ in which players are simultaneously interpreting and associating sounds with other events, objects, and emotions from the gaming experience. The right soundtrack or sound effect (SFX) can evoke or enhance different emotions – further enhancing the emotional appeal of KoGoNa (Caroux et al., 2015). KoGoNa’s original audio elements were limited to a simple click that accompanied a tile flip. The enhanced audio is interactive and event-driven, meaning the sound is initiated by the game or the player. A quick-tempo and upbeat background track will play during the game to evoke excitement and delight. The track will change to a slower tempo to create an atmosphere of ‘resting between rounds’ when the game is paused or when the menu screens are opened by the player. In contrast, new, quick-tempo tracks will be used to increase intensity as the player advances. The behaviours are known as system-controlled (game-generated) sonic response -specifically ‘adaptive audio’ [Collins, (2013), p.34]. Strategic manipulation of the game’s audio features addresses the concept of challenge and *progression* which is discussed in a later section. SFX also contributes significantly to engagement, perhaps more so than the music (Caroux et al., 2015). SFX in KoGoNa is used primarily to provide feedback to the player that their action was registered, and the game has responded. An example of feedback is the click of a button when it is tapped, or a noise the tiles make when they are successfully matched. It is very useful for players to know if a tap registered, and significantly enhances the sense of responsiveness and interactivity further contributing to the enjoyment of the game (Collins, 2013; Merikivi et al., 2017). More physical feedback could also be provided in the form of haptics, for example, the device vibrating in response to the player’s action further reinforcing the perception, interpretation, and engagement with the game (Collins, 2013). Feedback enhances game *flow* and is an important component in engagement (Perttula et al., 2017) as will be discussed under challenge and progression. KoGoNa’s visuals and audio have been

enhanced to achieve the goal of promoting *excitement* in players. These positive emotions should encourage them to continue playing the game and contribute to the experience of *game flow* which is discussed in a later section.

## 7 Challenge and progression

Bridges and Florsheim (2008, p.311) defined challenge as “a sense that one’s capabilities are being stretched” (Groening and Binnewies, 2019). Although Merikivi et al. found that novelty and ease-of-use were the *most* important factors behind enjoyment the same study noted that a game’s *challenge* is also an important factor. Challenge has been identified as the central precondition of flow experience (Perttula et al., 2017). Providing challenges is an essential element in the design of a simple game like KoGoNa in order to retain a player’s attention over the long-term. According to Seok and Dacosta (2015), players with higher levels of ‘openness to experience’ who enjoy approaching problems in unique ways are more likely to take an interest in KoGoNa’s if the game design involves some element of strategic problem-solving. Several solutions were implemented in the design enhancements.

In KoGoNa’s original design, the game board consisted of a very basic  $3 \times 3$  grid as shown in Figure 3

The player did not have any ability to select aspects of the game such as the grid size, which meant that the game’s challenge and novelty wore off quickly. This limitation was addressed by providing the player with the autonomy to select the difficulty level such as *easy*, *medium*, and *hard* in the main menu at the start of the game. This feature was implemented by adjusting the size of the game grid, from  $3 \times 3$  to  $5 \times 5$  to  $7 \times 7$ . The player could then play each subsequent round on the chosen difficulty until they return to the main menu. Features such as more colours to match, less time on the clock, random tile colour changes, or any combination of these options to increase the challenge were also added. However, this might lead to attenuated engagement, as the player’s skill increases with each round and the novelty and challenge decreases resulting in a loss of engagement that would be difficult to restore (Zohaib, 2018). A more effective solution would be to dynamically vary these features within or during a continuous round – a process called *dynamic difficulty adjustment (DDA)*. DDA seeks to maximise player engagement by automatically modifying a game’s features, behaviours, and scenarios in real-time, based on the player’s skill (Zohaib, 2018; Kristan et al., 2020). Dynamic modification provides a customised solution to manage player’s emotional engagement from simplistic through to more advanced game-play. A basic form of DDA could be implemented in KoGoNa by keeping track of how many tiles the player successfully matches and once a threshold is reached, new features, behaviours, and scenarios are automatically triggered to change up the gameplay. A combination of randomly selected modifications would be enacted so that the level of difficulty scales differently every time – such as increasing the matrix of tiles, tile colours, power-ups, intensity of haptic feedback and soundtrack tempo to increase excitement while signalling that a change has occurred to the player. A skilled player can match tiles much more quickly than a new or less skilled player thus reaching the threshold of increasing difficulty more quickly; allowing them to progress faster towards more challenging game scenarios. Conversely, less-skilled players will have the time they need to acclimate to the game; learning how to match tiles, use power-ups strategically before crossing the threshold and triggering

changes to the game-play (Zohaib, 2018). An effective DDA system would allow the player to experience increasing difficulty through multi-modal channels over the course of a single round of KoGoNa, without any need for pausing or selecting a new difficulty from the menu. This facilitates the creation of a *flow state*, one of DDA's goals (Zohaib, 2018), and the last piece in the puzzle that is KoGoNa's design.

## 8 The GameFlow model

The concept of *flow* originates in the work of Csikszentmihalyi (1991, p.3) and proposes an optimised state of being in which “a person's body or mind is stretched to its limits in a voluntary effort to accomplish something difficult and worthwhile.” The flow state is promoted through the gaming interface, sound effects, player interaction, game difficulty, and player skills [Perttula et al., 2017; Su et al., (2016), p.247]. The player is performing optimally and experiencing excitement and a high degree of focus (Su et al., 2016). This feeling may become so intense that, to the one experiencing it, nothing else matters except for maintaining the flow and continuing to perform to the best of their ability at whatever task they are doing (Perttula et al., 2017). A player who has entered their flow state is playing at the peak of emotional investment, and this is when they will be the most engaged in the game (Su et al., 2016). Games that can reliably induce flow in their players are considered some of the most successful and engaging (Perttula et al., 2017), therefore the creation of flow is the primary goal of KoGoNa. Sweetser and Wyeth's (2005) GameFlow model is a set of heuristics to guide the promotion of flow of game design. The model was purposefully chosen because of its general nature which is intended to be applicable to all game types, as well as its prevalence in the game design and user experience literature (Sweetser et al., 2017). Seven of the model's eight elements: concentration, challenge, skills, control, clear goals, feedback, and immersion guided the enhancements to KoGoNa and are used to summarise the enhanced features, behaviours, and scenarios of the game's design. The full table with accompanying criteria can be found here.

The GameFlow model's eight elements are:

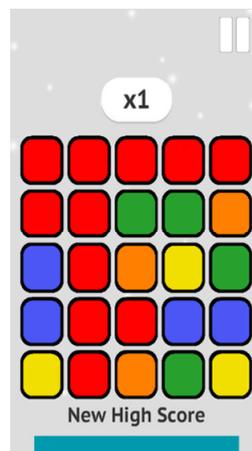
- 1 Concentration – Games should require concentration and the player should be able to concentrate on the game.
- 2 Challenge – Games should be sufficiently challenging and match the player's skill level.
- 3 Player skills – Games must support player skill development and mastery.
- 4 Control – Players should feel a sense of control over their actions in the game.
- 5 Clear goals – Games should provide the player with clear goals at appropriate times.
- 6 Feedback – Players must receive appropriate feedback at appropriate times.
- 7 Immersion – Players should experience deep but effortless involvement in the game.
- 8 Social interaction – Games should support and create opportunities for social interaction.

## 9 Analysis

This section describes how KoGoNa's design implements each element of the GameFlow model. The enhanced design directly addresses six of the eight criteria. The elements are not mutually exclusive; as discussed in the literature [Sweetser et al., (2017), p.21]. For example, the game's audio features provide both cues and *feedback* to the player as well as enhancing the *immersive* qualities of the game.

- *Concentration*: Dynamic background music, SFX, countdown timer, and coloured tiles provide multiple sources of stimuli. Simple icons show available features, behaviours, and scenarios such as power-ups and board reset. These auditory and visual cues direct and maintain the player's attention but are not excessive – they are only triggered in response to the player's behaviour and customised to match the player's ability.
- *Challenge*: DDA is used to maximise engagement by automatically modifying a game's features, behaviours, and scenarios in real-time in response to the player's skill. A basic form of DDA keeps track of how many tiles the player successfully matches and once a threshold is reached new features, behaviours, and scenarios are automatically triggered to change up the gameplay. The level of challenge increases at the player's pace as they progress through the game and increases their skill level while ensuring that the challenges are appropriate to the player's skill level.
- *Player skills*: The intuitive matching design of KoGoNa begins with simple instruction screens shown in Figure 8. Players are rewarded with increased time on the timer and the game tracks their high score. The swiping action to match tiles make the interface and mechanics simple and intuitive.

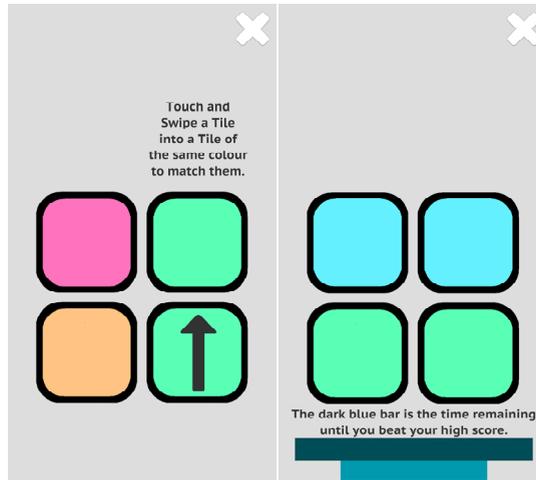
**Figure 8** KoGoNa Start screen using highly saturated tile colours (see online version for colours)



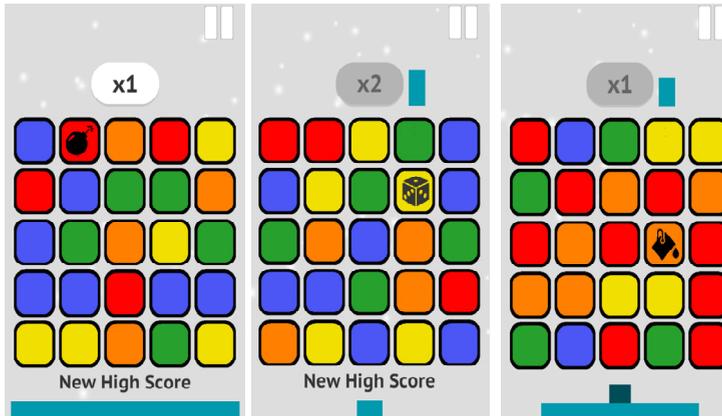
- *Control*: Player agency over the game interface is achieved through the intuitive input gestures that adhere to material design principles that support the best practices of user interface design. For example, the touch and swipe gesture do not require a high degree of precision, the UI elements, such as flipping tiles, respond to gestures in real-time providing direct player control of the touch interactions (Google, 2014).

Players have control over the start, stop, and save options. Player error is constrained to mismatching tiles or running out of the allotted time which results in the game ending and the option to restart the game. The core game-mechanic used in KoGoNa is *matching* (Trefry, 2010). The basic swipe to match tiles mechanism gives the player a sense of control over their actions and behaviours such as power-ups and an automatic colour matcher shown in Figure 9, can boost the player’s performance if they are used strategically.

**Figure 9** KoGoNa instructions (see online version for colours)



**Figure 10** Performance boosters, dice, bomb and bucket (see online version for colours)



- *Clear goals:* The basic mechanism of matching tiles makes the game’s singular goal clear. The game elements such as real-time response to matched tiles and timer bar that displays how much time is left keeps the player apprised of their progress towards their goal.

- *Feedback*: Feedback overlaps with several of the other elements and is embedded in the game design as audio and visual features.
  - a Direct manipulation of elements, such as flipping tiles, provides real-time feedback.
  - b Tile flips and successful matches are indicated by a sound effect.
  - c Dynamic music tempo and SFX changes in response to player's progression.
  - d Counter displays number of consecutive tile matches.
  - e Health points/Timer bar shows time increasing or time decreasing.
  - f Game over screen displays length of time played and current personal best time.
- *Immersion*: The literature on immersion suggests that it is not an easily measured, simplistic construct (Jennett et al., 2008; Abbasi et al., 2017), rather, studies indicate that it is a multidimensional construct collectively formed by factors such as *game flow*, *cognitive-absorption*, and *presence* (O'Brien and Toms, 2010) and with different levels, i.e., *engagement*, *engrossment* and *total immersion*. Brown and Cairns (2004) suggest that divergent meaning of immersion obfuscate its causes. This ambiguity makes a prescriptive approach to the design for immersion challenging. Immersion is a subjective, highly individualised experience which can be measured subjectively (through self-reports) or objectively (task completion time, eye movements, bio-metrics) (Georgiou and Kyza, 2017). It would be problematic to claim with certainty that the design of KoGoNa achieves immersion. Although immersion is an element in the GameFlow model, concerns about its validity have been raised in the literature and these concerns have been acknowledged by the creators of the model. The authors of this present study agree with Bleumers et al.'s (2010) suggestion to indicate whether KoGoNa *promotes* or *inhibits* immersion. Further, the authors recommend conducting a user test with a self-report questionnaire similar to the ARI by researchers Georgiou and Kyza (2017), the immersion questionnaire designed by Jennett et al. (2008) or the game experience questionnaire (GEQ) developed by Ijsselsteijn et al. (2008).
- *Social Interaction*. KoGoNa does not support multiplayer functionality therefore Social Interaction was not considered in the enhanced design.

## 10 Conclusions and recommended future work

Digital games researcher Mäyrä (2008, p.162) states, “[T]he main emphasis in game design is on producing games rather than research papers.” The *primary* goal of this research was to improve KoGoNa – not to produce academic research that is broadly applicable to game design scholarship. DDAR creates new knowledge through the lens of the designer-as-researcher – the artefacts of which are both the *product* and the *scholarship*. However, it is well-understood within the AR literature that these outcomes are intentionally limited to the context of the investigation. This study has focused exclusively on the design stage; therefore, the recommended next step is to validate the enhanced design through usability studies using a combination of user-testing and self-report surveys and *play-testing* [Mäyrä, 2008; Pozzi and Zimmerman, (2015), Chapter 5, p.177]. Results of these tests would not only validate the design decisions but

also further validate the collection of game design research that informed these decisions. Elements such as GameFlow, DDA; strategic use of colour; dynamic music tempo, and SFX; and real-time feedback promote *enjoyment*, *engagement*, and *flow* which are factors associated with successful monetisation in the mobile game industry. Some recommendations for the digital game design space are

- Designers should be cognisant of, and consult the game design research throughout the conceptualisation and development phases regardless of the game genre or mechanism.
- Design for ‘flow’ and immersion thereby incentivising continuous play, conversion and sharing with others.
- Build playtesting into the design process.

‘Road-testing’ the new DDAR methodology conducted by researcher-practitioners working at the intersection of design science and AR would add rigor, validity, and reliability.

## 11 Limitations

Critics of AR cite limitations in the objectivity of the practitioner as researcher in which the researcher is inside the context with ‘tacit knowledge of the situation’ [Mckay and Marshall, 2001; Pickard, (2017), p.163]. The product was designed by the developer/researcher and as such, it is characterised by “the active and deliberate self-involvement of the researcher in the context of his/her investigation” [Mckay and Marshall, (2001), p.47]. AR is inherently bounded by the immediate situation; using self-reported data which is rarely verified by an objective third party. However, it is well-understood within the AR literature that these outcomes are intentionally limited to the immediate research context (Pickard, 2017). DSR, whose goal is to create ‘a purposeful artefact’ that “must either solve a problem that has not yet been solved, or provide a more effective solution” [Hevner et al., (2004), p.82] complements AR. DDAR creates new knowledge through the lens of the designer-as-researcher – the artefacts of which are both the *product* and the *scholarship*. Finally, DDAR was developed specifically for this research and has not yet been widely ‘road-tested’.

The interaction design process used in game development is composed of different stages – one of which should include user testing. The capstone project constrained the design and development period to 12 weeks – essentially one academic term. The strict time limitations precluded the opportunity to conduct user testing for the purpose of validating the propositions and design decisions explicated in this study. As previously stated, this project would benefit from user testing such as A/B testing, interviews, questionnaires and usability studies.

## 12 Contributions

The contributions to this research project are shown in Table 1.

**Table 1** Authors' contributions to this research project

<i>Term</i>	<i>Definition</i>	<i>Contributor</i>
Conceptualisation	Ideas, formulation or evolution of overarching research goals and aims	A. Dorokhine and S. Bratt
Methodology	Development or design of methodology, creation of models	S. Bratt
Software	Programming, software development, designing computer programs, implementation of the computer code and supporting algorithms, testing of existing code components	A. Dorokhine
Formal analysis	Application of statistical, mathematical, computational, or other formal techniques to analyse or synthesise study data	A. Dorokhine and S. Bratt
Investigation	Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection	S. Bratt
Resources	Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools	A. Dorokhine
Data curation	Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later reuse	A. Dorokhine
Writing – original draft	Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation)	A. Dorokhine
Writing – review and editing	Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre- or post-publication stages	S. Bratt
Visualisation	Preparation, creation and/or presentation of the published work, specifically visualisation/data presentation	S. Bratt
Supervision	Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team	S. Bratt
Project administration	Management and coordination responsibility for the research activity planning and execution	S. Bratt

### 13 Lessons learned – time, team, and theory

A capstone project is inherently an opportunity to show what a student has learned through the course of a self-directed project. The overarching lesson was the value of time and how its scarcity impacts every aspect of product development. The capstone project was scheduled to be completed in one semester. Even though work began one month before the official start date, time remained a limiting factor throughout the project. For example, acquiring suitable sound effects and music tracks sourced from free sound libraries took longer than expected and the final selection was based on satisfying instead of optimal as the project deadline came before a satisfactory library was found.

More time should be allocated to acquiring resources. Another example was the inability to develop a haptic feedback feature due to time constraints.

Developing a mobile game – even with a simple game-play like KoGoNa is a significant undertaking. The challenge is amplified in an individual project in which one student is responsible for all aspects of the technical requirements and user interface. In retrospect it would have been preferable to develop this project as a team which included a digital experience designer and a visual designer in order to delegate tasks like the design of the UI and user testing.

A secondary goal of this project was to continue to bridge the gap between research and design practice. In retrospect it would have been advisable to do a deep-dive into the digital game design literature a priori beginning with the first iteration of KoGoNa developed during the internship and continuing through the capstone project. Computer science projects are inherently technical in nature. This prioritisation of *functionality* over interaction and the user interface resulted in compromises to the user experience. While the game design achieved the intended technical requirements it still needs attention to the user interface to optimise the user experience based on visual design principles, cognitive psychology, and usability principles. A small team with both a practical and an *academic* background in these disciplines combined with a longer project timeline would have supported interdisciplinary research and practice while providing the potential to extend the project's contribution to game design literature to a broader, more diverse audience of researchers and practitioners.

## References

- Abbasi, A.Z., Ting, D.H. and Hlavacs, H. (2017) 'Engagement in games: developing an instrument to measure consumer videogame engagement and its validation', *International Journal of Computer Games Technology*, DOI: 10.1155/2017/7363925.
- Adams, F.M. and Osgood, C.E. (1973) 'A cross-cultural study of the affective meanings of color', *Journal of Cross-Cultural Psychology*, Vol. 4, No. 2, pp.135–156.
- Adelman, C. (1993) 'Kurt Lewin and the origins of action research', *Educational Action Research*, Vol. 1, No. 1, pp.7–24, DOI: 10.1080/0965079930010102.
- Bleumers, L., Jacobs, A. and Van Lier, T. (2010) 'Criminal cities and enchanted forests: a user-centred assessment of the applicability of the pervasive GameFlow model', in *Proceedings of the 3rd International Conference on Fun and Games*, Association for Computing Machinery (Fun and Games'10), New York, NY, USA, pp.38–47, DOI: 10.1145/1823818.1823822.
- Bridges, E. and Florsheim, R. (2008) 'Hedonic and utilitarian shopping goals: the online experience', *Journal of Business Research*, Vol. 61, No. 4, pp.309–314, DOI: 10.1016/j.jbusres.2007.06.017.
- Brown, E. and Cairns, P. (2004) 'A grounded investigation of game immersion', *Conference on Human Factors in Computing Systems – Proceedings*, pp.1297–1300, DOI: 10.1145/985921.986048.
- Caroux, L. et al. (2015) 'Player-video game interaction: a systematic review of current concepts', *Computers in Human Behavior*, Vol. 48, pp.366–381, Elsevier Science, DOI: 10.1016/j.chb.2015.01.066.

- Catalán, S., Martínez, E. and Wallace, E. (2019) 'Analysing mobile advergaming effectiveness: the role of flow, game repetition and brand familiarity', *The Journal of Product and Brand Management*, Vol. 28, No. 4, pp.502–514, Department of Marketing, University of Zaragoza, Zaragoza, Spain; Discipline of Marketing, National University of Ireland Galway, Galway, Ireland; Department of Marketing, University of Zaragoza, Zaragoza, Spain; Emerald Group Publishing Limited [online] <http://dx.doi.org/10.1108/JPBM-07-2018-1929>.
- Collins, K. (2013) *Playing with Sound: A Theory of Interacting with Sound and Music in Video Games*, The MIT Press, Cambridge, Massachusetts.
- Csikszentmihalyi, M. (1991) 'Flow: the psychology of optimal experience: steps toward enhancing the quality of life', *Design Issues*, Vol. 8, No. 1, p.80, DOI: 10.2307/1511458.
- Georgiou, Y. and Kyza, E.A. (2017) 'The development and validation of the ARI questionnaire: an instrument for measuring immersion in location-based augmented reality settings', *International Journal of Human Computer Studies*, December, Vol. 98, pp.24–37, Elsevier, DOI: 10.1016/j.ijhcs.2016.09.014.
- Geslin, E., Jégou, L. and Beaudoin, D. (2016) 'How color properties can be used to elicit emotions in video games', *International Journal of Computer Games Technology* [online] <https://doi.org/10.1155/2016/5182768>.
- Google (2014) *Material Design* [online] <https://material.io/design/interaction/gestures.html> (accessed 19 April 2020).
- Groening, C. and Binnewies, C. (2019) '“Achievement unlocked!” – the impact of digital achievements as a gamification element on motivation and performance', in Groening, C. (Ed.): *Computers in Human Behavior*, Vol. 97, pp.151–166, University of Muenster, Institute of Psychology, Fliednerstr. 21, 48149, Muenster, Germany; Elsevier Science, DOI: 10.1016/j.chb.2019.02.026.
- Hevner, A.R. et al. (2004) 'Design science in information systems research', *MIS Quarterly*, Vol. 28, No. 1, pp.75–105.
- Huang, H.C. et al. (2018) 'How to create flow experience in exergames? Perspective of flow theory', *Telematics and Informatics*, Vol. 35, No. 5, pp.1288–1296, Elsevier, DOI: 10.1016/j.tele.2018.03.001.
- Ijsselstein, W. et al. (2008) 'Measuring the experience of digital game enjoyment', *Journal of Personality*, pp.7–8.
- Iqbal, M. (2020) *App Revenue Statistics (2019)*, Business of Apps [online] <https://www.businessofapps.com/data/app-revenues/> (accessed 5 May 2020).
- Jennett, C. et al. (2008) 'Measuring and defining the experience of immersion in games', *International Journal of Human Computer Studies*, Vol. 66, No. 9, pp.641–661, DOI: 10.1016/j.ijhcs.2008.04.004.
- Joost, G. et al. (2016) *Design As Research: Positions, Arguments, Perspectives*, Birkhäuser [online] <https://library.macewan.ca/full-record/nlebk/1229806> (accessed 9 May 2020).
- Kemmis, S. and McTaggart, R. (1988) *The Action Research Planner: Action Research and the Critical Analysis of Pedagogy*, Deakin University, Victoria.
- Kristan, D. et al. (2020) 'Creating competitive opponents for serious games through dynamic difficulty adjustment', *Information*, Vol. 11, No. 3, Switzerland, DOI: 10.3390/info11030156.
- Lewin, K. (1946) 'Action research and minority problems', *Journal of Social Issues*, Vol. 2, No. 4, pp.34–46, DOI: 10.1111/j.1540-4560.1946.tb02295.x.
- Lewin, K. (1946) 'Action research and minority problems', *Journal of Social Issues*, Vol. 2, No. 4, pp.34–17 [online] <https://doi.org/10.1111/j.1540-4560.1946.tb02295.x>.
- Mäyrä, F. (2008) *An Introduction to Game Studies*, SAGE Publications, London, UK [online] <http://ebookcentral.proquest.com/lib/macewan-ebooks/detail.action?docID=448458> (accessed 1 May 2020).
- Mckay, J. and Marshall, P. (2001) 'The dual imperatives of action research', *Information Technology & People*, Vol. 14, No. 1, pp.46–59, DOI: 10.1108/09593840110384771.

- Merikivi, J., Tuunainen, V. and Nguyen, D. (2017) 'What makes continued mobile gaming enjoyable?', *Computers in Human Behavior*, December, Vol. 68, pp.411–421, Elsevier Ltd, DOI: 10.1016/j.chb.2016.11.070.
- Moch, S.D. et al. (2016) 'Use of action research in nursing education', in Kukkurainen, M.L. (Ed.): *Nursing Research and Practice*, Hindawi Publishing Corporation, p.8749167, DOI: 10.1155/2016/8749167.
- Muriel, D. and Crawford, G. (2020) 'Video Games and Agency in contemporary society', *Games and Culture*, Vol. 15, No. 2, pp.138–157 [online] <https://doi.org/10.1177/1555412017750448>.
- O'Brien, H.L. and Toms, E.G. (2010) 'The development and evaluation of a survey to measure user engagement', *Journal of the American Society for Information Science and Technology*, Vol. 60, No. 1, pp.50–69, DOI: 10.1002/asi.21229.
- Pappas, I.O. et al. (2019) 'Explaining user experience in mobile gaming applications: an fsQCA approach', *Internet Research*, Vol. 29, No. 2, pp.293–314, DOI: 10.1108/IntR-12-2017-0479.
- Perttula, A. et al. (2017) 'Flow experience in game based learning – a systematic literature review', *International Journal of Serious Games*, Vol. 4, No. 1, pp.57–72, DOI: 10.17083/ijsg.v4i1.151.
- Pickard, A.J. (2017) *Research Methods in Information*, Facet Publishing, DOI: 10.3163/1536-5050.96.1.70b.
- Pozzi, N. and Zimmerman, E. (2015) *Games | Game Design | Game Studies : An Introduction. In Game Design | Game Studies. An Introduction*, EBSCOhost [online] [library.macewan.ca/full-record/cat00565a/8972176](http://library.macewan.ca/full-record/cat00565a/8972176).
- Seok, S. and Dacosta, B. (2015) 'Predicting video game behavior', *Games and Culture*, Vol. 10, No. 5, pp.481–501, DOI: 10.1177/1555412014565640.
- Sepulveda, G.K., Besoain, F. and Barriga, N.A. (2019) 'Exploring dynamic difficulty adjustment in videogames', in *2019 IEEE CHILEAN Conference on Electrical, Electronics Engineering, Information and Communication Technologies (CHILECON)*, pp.1–6, DOI: 10.1109/CHILECON47746.2019.8988068.
- Statista (2019) *Mobile Gaming – Statistics & Facts*, Gough, Christina [online] <https://www.statista.com/topics/1906/mobile-gaming/> (accessed 2 May 2020).
- Statista (2020) *App Store and Google Play Mobile Game Downloads Worldwide 2018–2019* [online] <https://www.statista.com/statistics/661553/global-app-stores-mobile-game-downloads/> (accessed 2 May 2020).
- Su, Y.S., Chiang, W.L., James Lee, C.T. and Chang, H.C. (2016) 'The effect of flow experience on player loyalty in mobile game application', *Computers in Human Behavior*, Vol. 63, pp.240–248 [online] <https://doi.org/10.1016/j.chb.2016.05.049>.
- Sweetser, P. and Wyeth, P. (2005) 'GameFlow: a model for evaluating player enjoyment in games', *Computers in Entertainment*, Vol. 3, No. 3, p.3, DOI: 10.1145/1077246.1077253.
- Sweetser, P. et al. (2017) 'GameFlow in different game genres and platforms', *Computers in Entertainment*, Vol. 15, No. 3, pp.1–25, DOI: 10.1145/3034780.
- Trefry, G. (2010) *Casual Game Design: Designing Play for the Gamer in All of Us*, Taylor & Francis Group, Boca Raton, FL.
- von Goethe, J.W. (1841) *Theory of Colours*, John Murray. London.
- Wilms, L. and Oberfeld, D. (2018) 'Color and emotion: effects of hue, saturation, and brightness', *Psychological Research*, Vol. 82, No. 5, pp.896–914 [online] <https://doi.org/10.1007/s00426-017-0880-8>.
- Zohaib, M. (2018) 'Dynamic difficulty adjustment (DDA) in computer games: a review', *Advances in Human-Computer Interaction*, DOI: 10.1155/2018/5681652.