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WHAT CAN ENGINEERING DESIGN LEARN FROM GAME DESIGN AND ITS PRACTICE?

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1. Introduction

While there is no doubt that the knowledge base and formal techniques in engineering design are far more comprehensive compared to game design and that game design can, and has been adapting and adopting tools and techniques from engineering design and other more mature design disciplines [Lankoski 2010], this paper contends that engineering design can also benefit from taking a closer look at the design and development of games. At its core, game design is an activity similar to engineering design, or any other design field, with the differentiation that the form and content are specific to the game design context. This grounds game design in the large body of existing design research, aiding in the identification of crucial activities, forms, contents, and context that determine the nature of game design [Kuittinen and Holopainen 2009], [Lankoski 2010] while simultaneously opening up elements of game design to other design disciplines. Additionally, conference papers on varying game design aspects have recently been published by the Design Society [Woo et al. 2014], [Silva Bernades and de Oliveira 2015] and [Wang and Chieh 2015].

From video games to card games and word games, whatever the game type, the objective of designing games has always been to create that elusive combination of competition, challenge, and interaction that players simple call 'fun'. Perhaps it is due to this association with fun, or that it is frequently viewed as having a focus on the 'non-serious' field of games, that despite games being centuries old, the academic study of how games are designed is a relatively young when compared to the academic study of the creation of other cultural forms, such as music and literature. In its academic infancy, game design is certainly not as well established as other disciplines, which makes it difficult to not only execute, as game design teachers are still learning what its best practices are and how to pass them on [Ham 2015], but also to discourse about as proper vocabulary to describe it is lacking [Burkart 2005], [Zagal et al. 2005], [Almedia and Cerrea da Silver 2013].

Looking beyond the study of games in and of themselves, as experiences that entertain, explore complex topics and communicate profound ideas, games are worth studying as artefacts of advanced digital technology, for their potential to educate, and as products within a thriving global economy. Research into game design is driven on the one hand by companies who crave tools that allow them to improve production and reduce the risks of investment in new projects and on the other, by independent developers who seek tools that can bring them productivity and direction [Almedia and Cerrea da Silver 2013]. It not only aims to bridge the gap between academia and industry but also to contribute to building a universal knowledge base of game design as the range of design centred techniques and tools in game design are still limited.

The focus of this paper is to critically look at the practice of game design through the analytical lenses of engineering design with the aim of distilling lessons that can be beneficial to engineering design while simultaneously connecting engineering design to game design studies. The paper opens with an

introduction to the field of game design as a discipline before breaking down games into the core elements that game designers are responsible for creating. Following that, the video game development process is analysed, with ties made to various product development methods.
An in-depth analysis of game designers and their design process is also undertaken before an original case study of the development of a game is presented. While the context within which engineering design is conducted undoubtedly differs from that of game design, through the exploration of game design as a creative practice, in addition to making a case for the possible viability of utilising game development methodologies in engineering development, the paper concludes by making inferences that contend that adopting some aspects from the culture and mentality of game designers could be of benefit to engineering designers are made.

2. Game design as an academic discipline

From a research standpoint, game design falls into the domain of game studies; the academic field that is concerned with the critical study of games. Game studies places emphasis on the ludic elements of gaming over its narrative elements; like the games it studies, it is not about the story and discourse but rather about actions and events. Focusing on the study of games, game design, players, and their role in society and culture, game studies is an inter-disciplinary field comprised of researchers and academics from a multitude of other areas such as computer science, psychology, sociology, anthropology, philosophy, arts and literature, media studies, and communication.
Despite being a universal part of human experience and a presence in all cultures, which can be attested to date back as early as 3600 BC [Piccione 1980], prior to the late-twentieth century and the advent of video games, the academic study of games was rare and limited to fields such as anthropology and history [Zagal et al. 2005]. The video game revolution of the 1980s saw an increased academic interest in games, resulting in the formation of the field of games studies that drew upon a diverse range of methodologies and schools of thought. These influences can be generally categorized in the following manner: the social sciences approach, the humanities approach and the industry and engineering approach [Konzack 2007]. Broadly speaking, the social scientific approach is concerned with the question of "What do games do to people", it heavily utilises tools and methods such as surveys and controlled laboratory experiments, and has sought to shift from simplistic ideas of games as either 'positive' or 'negative' by seeking to understand the role and of gaming in the complexities of everyday life [Crawford 2012]. Generally, the humanities approach concerns itself with the question "What meaning are made through games?" and through the use of interviews, ethnographies and participant observation, researchers investigate the various roles that games play in the lives of people along with the meaning they assign to their experiences [Consalvo 2007]. The last one, the industry and engineering approach to game studies, is harder to encapsulate through a single question. The engineering perspective of games studies is particularly concerned with video games as the context for a wide array of technological innovations and advancement in areas such as computer graphics, artificial intelligence, and networking [Konzack 2007]. From an industry perspective, game studies research delves into games as products that are created and sold for consumption [Konzack 2007]. This industrial slant can be characterized as 'product' or 'design' driven. Research within this domain mainly deals with addressing the questions centered on "How can better games be created?" and "What makes a good game?" Studies from this perspective have included describing and defining how to design games [Crawford 1984], [Rollings and Moris 2000], [Rouse 2004], abstracting commonalities from games and understanding how they relate to each other [Björk and Holopainen 2004], [Zagal et al. 2005], extracting guidelines and rules for making better games [Fabricatore et al. 2002], [Zagal 2010] and studying the player experience [Pagulayan et al. 2003], [Koster 2004]. Additionally, various attempts have been made to define and construct a vocabulary for describing games and thinking through the design of new ones [Burkart 2005], [Zagal et al. 2005].
Falling within the domain of the engineering and industry approach to game studies, game design can be defined in the broadest sense as the application of design and aesthetics to create a game that facilitates interactions between players. While game design typically relates to game creation for entertainment purposes, gamification applies game design elements and game principles to non-game contexts for medical, educational, experimental or other purposes [Huotari and Hamari 2012]. Game

studies is not to be confused with game theory which, is academically defined as "the study of mathematical models of conflict and cooperation between intelligent rational decision-makers" [Myerson 1997] and focuses on the study of strategic decision making in primarily non-game situations.

3. Game classification and characterisation

A game can be defined as “a system in which players engage in artificial conflict, defined by set rules, that results in a quantifiable outcome” [Salem and Zimmerman 2003]. In the realm of play and entertainment, games can take a variety of forms; Table 1 outlines examples of the major types of games.

Table 1. Types of games and their examples

Game Type	Table Top	Party	Digital	Other
Examples	Board Games	Pub Games	Console Games	Sports
	Card Games	Drinking Games	Computer Games	Casino Games
	Dice Games	Daring Games	Mobile Games	Role Playing Games
	Tile Games	Guessing Games	Arcade Games	Puzzles

Regardless of type, the key components of games are the goals, rules, challenge, and interaction and games generally involve mental or physical stimulation, and often both, that produces desirable interactions among its participants, and possibly spectators. While games are often classified by the tools that are required to play them, such as a board and pieces, cards, or a computer, they are characterised by the gameplay, or “what the player does” [Crawford 2003] and defined by their rules. Rules largely determine each player’s goal, player’s turns, and the rights and responsibilities of the players and outline the victory conditions. A combination of game rules and tools results in a game where success is determined by skill, luck, strategy, or a combination thereof. While most games require multiple players, single player games such as puzzles exist and they pose a unique challenge to players compared to their counterparts. Where players compete with or against each other to reach the game’s goal in multiple player games, in single player games the player goes up against an element of the environment (an artificial opponent), their own skills, time or chance.

3.1 Elements of a game

A game is made up of elements, and when designing a game it is a combination of these that the designer sets out to establish in a manner that results in the desired player experience. Figure 1 is a model of game elements in the form of a Venn diagram, showing the interactions between the different elements; the elements are described in Table 2.

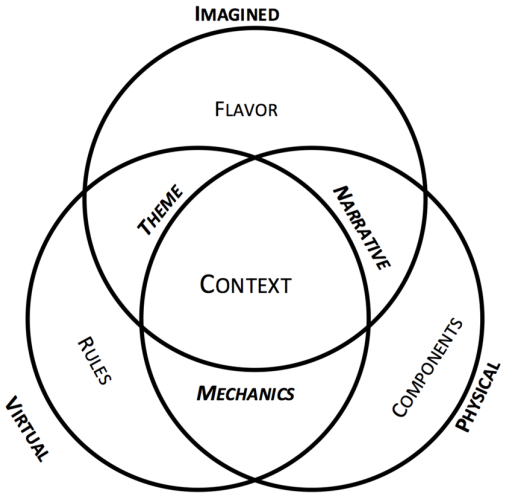

Figure 1. A model of game elements (modified from Major [2014])

Table 2. Description of game elements

Element	Description
Components	Tools that make up the game, existing purely in the physical circle which deals with real world parts of the game e.g. card, boards, players etc.
Flavor	The thematic detail that has no impact on how the game plays, existing purely in the imagined circle which deals with player emotions and feelings e.g. art in the rulebook.
Rules	Theoretical system or parameters of the game, existing purely in the virtual circle which deals with concepts being introduced to the player e.g. "select one option and pass rest"
Imagined + Virtual = Theme	Where flavour has no impact on the game, theme does. It set up parameters for what the player should expect to take place, including behaviours and interactions e.g. a zombie theme would probably include the expectation of suspense, but not include the expectation of political intrigue.
Imagined + Physical = Narrative	The unique sequence of events that players experience during any specific game session. In a themeless, abstract game, it is the actions that players take, such as "I place my stone at the intersection of the 4th row and the 5th column." But a theme changes this and it becomes something like "I build my settlement by the wheat, sheep, and wood".
Physical + Virtual = Mechanics	Where the rules set up the game's conceptual parameters, the mechanics are the game's engine. Mechanics are an interactive concept; they determine how the players can use the rules to come up with strategy e.g. roll a double or pay £50 to exit jail.
Context	At the intersection of all three circles is the context; this is how the players understand the game as a whole and their role in it.

As they are easy enough to understand, simple games may not require a strong theme. The more complex the game's mechanics become, the more important the theme becomes because of how it modifies and builds the context [Salem and Zimmerman 2003]. This can also allow personal narrative, such as how well the players know each other, to take precedence. Even abstract games have context, and a theme can alter the context of the game to make social interactions less contentious. When the theme is absent, there is less of a buffer and the game becomes more competitive. However, when the theme is poorly matched to the mechanics and the narrative, the context suffers; a weak theme makes the player question why they do not have options that they think they should have for their role and goals, creating dissonance and an imbalanced context. For the game designer, the trickiest thing to affect is the narrative as it is mostly reliant on the players and not the components [Jenkins 2004].

Games are complex entities and it is important that the designer has a firm understanding of how the physical parts, the imagined parts, and the ways that the players interact with the game all have an effect on each other. "What should the designer focus on?" tends to be a polarising question within the game design community, but the reality is that it doesn't really matter. Focusing on the mechanic makes sense if the play experience is to be driven by more intellectual activity, and theme as a starting point makes sense if the play experience is to be driven by the imagination [Rouse 2004]. The design process can start from any of the game elements, the important thing is that the designer quickly reaches the point where everything is tied together with a strong context and that the integrity of the context is maintained as different parts are changed and added to the game [Major 2014].

4. Research methodology, data collection and results

This research study explores and investigates the field of game design and its practice with an aim of connecting engineering design to game design studies and distilling lessons from game design that can be beneficial to engineering designers. It is a mixed mixed methods study composed of three different phases that fulfil different purposes.

The first phase, focused on gaining insights and familiarity into the game development process and relating them to the engineering development process where appropriate, adopts a literature-based methodology. As the rise of game design as an academic discipline is intertwined with the rise of video games [Zagal et al. 2005], exploring the development of video games provides the most holistic view of

the game development process. During this phase, relevant literature was collated and meta-synthesis, a non-statistical technique that integrates, evaluates and interprets findings from multiple literature sources, was used in order to identify common core elements and themes of the video game development process and where appropriate, relate them to engineering development.
Archival interviews of independent board game designers make up the second phase whose aim is to explore the game design process. Many of the design lessons that are learnt by making and playing tabletop games can be applied to other game types, making working with tabletop games an ideal way to develop game design skills that are applicable in multiple realms [Ham 2015]. It is for this reason that board game designers were selected as the ideal type of game designer whose design process was to be examined. Interviews of 49 independent board game designers, mainly focus on the game designers' profiles, the process they adopt when they are designing games, and what skills they think are key to successful game development, were collated. The interview transcripts were qualitatively analysed in NVivo using a thematic analysis approach, the thematic codes that were outputs from the qualitative analysis were then quantitatively analysed.
The final phase is an original in-depth case study of the design and development of digital-tabletop hybrid game that is informed by an array of project documents and interviews with project team members. The aim of this phase is to explore the dynamics of undertaking the design and development of a game as part of an interdisciplinary team which includes game, product and engineering designers. This phase of the research study is still ongoing as the game development is still progressing. Within this paper a case report containing, a narrative of the case, built from project documents and informal conversations, and reflections of two team members gathered from interviews will be presented. The case report focuses on the pre-development phase of the game's development, it is retrospective from the point when all the major gameplay elements were functional and the game was ready to move into the next development phase, the production phase.
The diversity within this three phase approach will bring together game design, game development, tabletop games, digital games, game designers and engineering designers in a manner that will allow for the distilling of lessons from game design and its practice that can be beneficial to engineering design while simultaneously connecting engineering design to game design studies.

5. Results and findings

The following sections outlines the key results and findings from the three different phases of the data collection and analysis.

5.1 Phase 1: Video game design process literature meta-synthesis

At the advent of the video game era, game production was a relatively simple process, often with one person designing, writing code, generating art assets, and testing the functionality of a single game in as little as six weeks [Chandler 2008]. These days, as players have come to expect totally immersive games that deliver more than great game play, many more people must be involved in the game production process. With no standardized process that ensures the successful and on time completion of every game [Bethke 2003], as game design is not a science, an exploration of the game development process shows that developers are getting better at game production, not only because they are learning from their mistakes, but also because they are looking to other disciplines for methods to create a more efficient development process [Bates 2004].
While the process differs from project to project, game development typically begins with defining the initial game concept and ends with the creation of a gold master of the final game code, with everything else happening in-between. Regardless of project dependent variables, a basic framework exists for the overall development process; the process of game development as an activity can be broken down into three broad phases: pre-production, production and post-production [Bates 2004]. With commencement to the next stage dependant on the accomplishment of several goals, the successful completion of each phase directly affects the successful release of the game. This is not too dissimilar to the engineering development process which typically begins with the establishment of design requirements and ends with the creation of production documents of the final solution [Ungera and Eppinger 2011].

Regardless of whether it is explicit or not, all artefacts are created through some design methodology. From building a physical prototype to architecting a software interface and implementing a series of controlled experiments, design methodologies guide the creative process and help ensure quality work. Over the years, practitioners and researchers have identified the need for formal models and tools to support game design [Almedia and Cerrea da Silver 2013]. There are currently a variety of methodological approaches to the game development process that have been developed and utilised; most often, these are attempts to re-imagine existing practices in other fields and industries to the video game industry. In their quest to attain organised, standardised and structured models and tools to aid the game design methods, they have at times turned to engineering design. Some of the methodologies utilised during game development bear resemblance to product development procedures and methods that engineering companies use to design and bring new products to market. Serving as a means of bringing the game through the three stages of development, some of the methodologies take the form of stage models where the design moves through distinct stages linearly from one stage to another, while others are iterative and adopt a cyclic process where the product is continually refined based on the results of testing the most recent iteration of the design. The waterfall model [Kuittinen and Holopainen 2009], similar to the stage-gate model in engineering design [Ungera and Eppinger 2011], is an example of stage models. It is a linear model where stages are generally separate and development flows sequentially from start point to end point. Typical stages include idea generation, concept generation, designing, prototyping, and playtesting. Stage models can be advantageous as they can be used to describe the different kinds of actions and competences required during the different stages [Kuittinen and Holopainen 2009] however, proponents of iterative models suggest that they are too rigid [Cerny and John 2000] and [Salem and Zinnerman 2003]. Through the iterative method [Salem and Zinnerman 2003], based on an iterative model, the game design emerges through rapid evolution and iteration of concrete prototypes ranging from simple paper ones to complex, and almost finished, software implementations. The game is repeatedly proposed, prototyped, play tested and re-evaluated prior to working product release. This method is similar the iterative design in engineering design [Ungera and Eppinger 2011].

The vertical slice method [Chandler 2008], where once the core game design has been completed, cross functional teams focus on creating a 'vertical slice' of the game (this is usually a feature such as combat, shooting, driving mechanic etc.). Each slice polished until complete, reinforcing the iterative process. The agile method [Bates 2004] and its variant, SCRUM [Chandler 2009], have their roots in software development. The agile method is an incremental iterative approach where there is no predetermined course of action; designers are free to respond to changes in requirements as they arise and make changes as the project progresses. It promotes adaptive planning, evolutionary development, early delivery, continuous improvement, and encourages rapid and flexible response to change. In SCRUM, the team members are organised into small cross-functional teams, typically organised around game features, that prioritise their work each day and embrace iteration. This allows a large number of creative people to work effectively on a project without the burdens of too much top– down management; a similar approach can be seen in engineering design during flexible product development [Smith 2007]. The Cerny method [Cerny and John 2000], developed especially for game development, advocates for an extensive pre-production phase where the focus is on producing a game design that may or may not result in a playable game. Technical constrains are only considered after the game has been designed and the development of the game is carried out using more rigorous design methodologies. Another methodology is the playcentric approach [Fullerton 2014], an iterative approach that focuses on the involvement of the player in the development process, from conception through to completion' early prototyping and playtesting are key components. This approach is similar to activity-centred design in engineering design [Saffer 2009].

The distinction between the models can be blurry as even in the case of iterative process models the stages within one iteration are clear (design, test, and analyse) and in staged models, regardless of being difficult or expensive it is it is sometimes necessary to revisit design issues from previous stages. Additionally, game development usually involves an overlap of these methods [Bates 2004]. For example, during the development of a single game the Cerny method can be used to create the game design, the water fall method can be used during asset creation when requirements are clear and

playtesting can be used during gameplay design. While there is no doubt that adopting formal methodologies has benefits for individual and group development project alike, as adopting a poor development methodology is likely to result in time and budget overruns and quality issues [Bethke 2003], prolific game designers such as Shiguri Miyamoto, Will Wright, and Sid Meir and independent game developers do not adopt to any formal design methodologies. They favour taking an organic approach to game design, a "start a game and go…" approach involves not adopting any specific process.

5.2 Phase 2: How board game designers design interviews

Game design is a creative practice that has an intrinsic reliance on the designer's creative skills, and with 70% of the game designers citing "*it allows me to be creative*" as the reason why they design games, game designers are in turn reliant on the game design practice as an avenue for creative expression. While none of the designers proclaimed that they followed any standardised process when designing games, all of the processes that they described can be categorised as being iterative and playcentric with early prototyping. Coincidentally this non-process oriented, or organic, approach is similar to that adopted during the development of FB, the retrospective process categorisation is identical too.

> *"What I have learned over time is to not rely on one strength, and not to have one fixed methodology when designing games. Designing games is not a science where you have a specific method that you always repeat." – Board Game Designer*

The designers typically start off the design process with ideation, most commonly centred on an interesting mechanic, a theme, rules or an already existent game. This leads to the creation of a rough prototype which embodies the essential system elements, the aim is to get to the prototyping phase as soon as possible as this allows them to playtest the game, first alone and then externally. From this point, an iterative cycle of refine-playtest-feedback-refine then begins and continues until the gameplay is set and the game enters the production phase. The design document, which is key in video game production as it captures all the ideas pertaining to the game in one document allowing all those involved to have a unified view of the game, was only mentioned once in the board game designer interviews. Perhaps not coincidentally, this was by designer that designs as part of a duo, as opposed to most of the other designers that predominantly work alone. 84% of the designers work solo and of those 96% have collaborators that they call upon and work with under certain situations. Through collaboration, the designers claim they can be more creative, generate and develop better ideas, perform more robust testing, and get help in areas where their skills might be lacking, but they have to contend with egos and co-ordination issues. While artistic skills such as story writing and graphic design were commonly cited as skills necessary to a game designer, patience and good written and oral communication came up top as skills that most the designers wish they had more of. With only 20% of those interviewed working full time as game designers, time is the main challenge that was faced by most of the independent designers.

5.3 Phase 3: fabulous beasts game development case study

Inspired by indigenous creation myths, Fabulous Beasts (FB) is a staking game that combines elements of tabletop dexterity and digital strategy games into a new kind of connected play; the systemic complexity of computer games is augmented with a physical, social play experience. Players take turns to build a tower by balancing plastic blocks on top of each other. Each played physical piece has an impact in the digital part of the game, which is playable on a mobile device connected via Bluetooth, all with the aim of building the most fabulous beast-filled world before the tower collapses. The tower rests on a smart sensing platform, which translates every piece into an equivalent in the connected digital world. As players build the tower it becomes more elaborate and complex and consequently the digital world being created becomes higher scoring. The goal of the game is to get the highest score before the tower falls down. The basic pieces in the game, which are each identified via an embedded RFID (radio-frequency identification) chip, consist of different animals.

Behind the development of FB is a six-person interdisciplinary team comprised of game designers, product designers, engineering designers and graphic artists. With the project falling within the realm of independent game development, the team faced many of the challenges associated with game

development without significant financial support from a publisher; additionally, the team had to adhere to a strict timeline due to funding constraints. The FB team were only able to pioneer this new style of play because hardware prototyping technology and advanced digital tools are increasingly becoming accessible and affordable to independent designers.

"We now have a set of tools at our disposal that allow us to design, prototype and scale very rapidly. On the one hand we have electronics prototyping tools like Arduino, on the other we can create and test pieces using a 3D printer and then of course there is a linking software layer that hinges the rest of that together." – FB Game Designer

The relative ease of prototyping lead to prolific iteration, multiple versions of the game and rules were developed driven by the outcomes of playtesting with the tangible blocks. As the game theme and mechanics evolved, they had an effect on the tangible blocks, the user interface design, the screen graphics and the electronic system (the platform design and its code). As the game was being developed, it was playtested monthly by group of 8-12 year olds who made up the primary target audience. Through the playtesting, the team was able to receive instant feedback on what the players thought of the game and they could see immediately if they were achieving their player experience goals. While in hindsight FB's development process can be classified as being iterative and playcentric with early prototyping, during the fact, the process was organic and not guided by any of the typical video game development methodologies. Due to the relatively small size of the project, it was decided that an organic, or non-process oriented, approach to the game development would be adopted. The genesis of the game design was the mechanics, formed by a combination of balancing and stacking and competitive item collection. At the end of the pre-production phase, when all the major gameplay elements were functional, two FB engineering designers were able to reflect upon their experience of working on a game design project and comparisons with engineering design. Their main reflections can be summarised as follows:

"My reflections on game design are formed around the culture, the design language used, user testing, and iteration." - FB Engineering Designer 1

"Game designers definitely have a different way of doing things compared to what I am used to; they tend to be less systematic which in a way allows them to be more creative" – FB Engineering Designer 2

For the engineering designers, what the game designers did during the early creative stages of the design process was of more interest than the approach adopted during the game development process. Due the the similarities between engineering development and game development approaches, the engineering designers were comfortable with the overall development approach.

6. Discussion and outputs: Lessons for engineering designers from game design

Through the meta-syntheses of game and engineering development methods, a connection was made between the game design as a field and engineering design. A number of game development methodologies share similarities with engineering development methodologies, with game developers frequently looking to engineering design to find formal methods to adopt during the development process. The compatibility of certain engineering development methods with game development suggests that the reverse might be true; methodologies, such as the Cerny method, created specifically for game development might also be applicable within engineering development.

Game development methods may be viable alternatives to engineering development methods – Lesson 1

As a phase that is still in progress, more insights are yet to be gleaned from the FB case study; however, the reflections of the design engineers that worked with game designers during the pre-development phase make a strong case for the importance of exploring the mentality and culture of game designers. From the perspectives of the engineering designers, the early creative stages of the game development process were particularly interesting as the game designers adopted interesting approaches to the game design.

The mentality and culture of game designers can offer engineering designers valuable insight into embedding creativity into engineering development – Lesson 2

Through the analysis of the board game designer interviews, real insight was gained into the aforementioned culture and mentality of game designers. While passion for gaming is a strong motivator

for most game designers, the pleasure of playing games being deeply intertwined with making them can blur the designer's judgment, as being a consumer is different from being a creator. However, with creators being so closely linked to consumers, there is a sense of community around game designers. It is one where sharing, openness and 'stealing' ideas are encouraged; their vested interest to see the development of games that they would like to play results in the development of new titles and the growth of the industry. Game designers glean inspiration from a myriad of sources such as books, movies, music and real world facts and culture, which is not unusual, however what is perhaps singular is the use of existing games as a foundation for new game; a practice that is prevalent and openly discussed. In the vein of writers with writing workshops and painters in art critiques, game designers are open with the community about their game ideas, allowing them to learn about what works and what doesn't and gain constructive criticism from other professionals. There is an ownership that comes with designing products and this sharing and openness stems from moving away from that by distinguishing the development of an idea from the development of a product. As abstract systems that do not have to conform to anything except self-imposed theory-based constraints, developing ideas is about a platonic ideal where one is not required to be concerned with practicality. This means that developing ideas can be separated from designing products. Viewed as an artistic sketch to be used as fodder during the very involved process of developing a product, when developed by separate entities the same idea rarely results in the germination of identical products. Due to the role that interpretation plays, a product design cannot be stolen from an idea; varying interpretations result in differing products. The reinforcement of this notion has the potential to result in the manifestation or growth of sharing and openness within engineering designers on a personal level. This captures the present zeitgeist, one which advocates for cooperation and breaking down boundaries as exemplified by practices such as open innovation, open access and open sourcing.

As the same idea rarely results in identical products, distinguish the development of ideas from the development of products to allow for sharing and growth among engineering designers – Lesson 3

In the ideation phase, with the practical element absent, everything is in flux with early prototyping allowing designers to test out ideas. During this phase, game designers tend to adopt a specific type of patience: patience with their ideas. Instead of completely discarding it, it is not uncommon for a game designer to set aside an idea that is not working with the intention of revisiting it later, nor is it uncommon to set aside a working idea with the same intention. While it might seem at odds with the common objective of reducing product time to market by speeding up the development process, patience with ideas can serve an important role for engineering designers. As they try to figure out what works and what doesn't, time becomes a valuable tool that allows them to detach from ideas and concepts; the distance offered by time allows for a fresh perspective, one where the designer can discern if they missed something in the ideas they discarded or if the ideas they are pursing are the most appropriate. It is a form of iteration that allows for revision in the quest to meet design objectives amidst changing contextual factors as the development process progresses.

Have patience with ideas as time away can allow you to detach from an idea and revisit it with a fresh perspective. What might seem like a good idea, or vice-versa, at one point in time might not be upon reflection – Lesson 4

7. Conclusions and further work

Through the engineering design lens, the aim of this research project is to gain an understanding of the field of game design and to distil any valuable insights from game designers, their culture and practice of their flavour of design. Split into three different phases, the outputs of two of the study's phases have been presented in this paper, with the third phase to be completed. To conclude the study, game design as collaborative practice that involves different stakeholders and requires multi-disciplinary teams will be explored. This will be achieved by interviewing the rest of the Fabulous Beasts team members and analysing their reflections and the different perspectives they adopted, this phase of the research will explore how the subjective nature of the design activity transforms the design process into a social process where individual interpretations of design situations play an important role and how a common understanding of the design situation arises. Upon completion of the project, a comprehensive set of

lessons from game design will be put forth covering the development process, the creative design process and the collaborative process, for the benefit of engineering designers.

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