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Larsen, L. J., & Majgaard, G. (2016). Expanding the Game Design Space – Teaching Computer Game Design in Higher Education. *Designs for Learning*, 8(1), 13–22, DOI: http://dx.doi.org/10.16993/dfl.68

RESEARCH

Expanding the Game Design Space – Teaching Computer Game Design in Higher Education

Lasse Juel Larsen* and Gunver Majgaard*

This article considers game design research in educational settings. Its focus is on how undergraduate students – particularly engineering students – learn computer game design. From observations conducted during our game design courses we have developed a model of expanded game design space. It encapsulates the entire development process from the first ideas to the final game with emphasis on game design thinking. Our model of expanded game design space consists of four separate – yet interconnected – layers in the process of game development. The first layer addresses the importance of framing, providing a clear game design assignment that involves the formulation of intended player experience and a description of game mechanics. The second layer focuses on game design thinking from six different aspects of game design chosen in relation to the framing of the game design assignment. The third layer establishes correspondence between formal elements of computer games and the structure of problem-based creativity. It addresses how game design challenges should be formulated and how creative solutions can be measured. The fourth and final layer demonstrates how clear framing can act as a guideline for evaluating game design thinking and for measuring solutions made in the development process. To strengthen our model of expanded design space, we will present examples from our game design courses.

Keywords: game design; computer games; design space; learning; education; creativity

Introduction

In recent years interest in game design has grown considerably. Despite this increasing interest, little research has been carried out about game design thinking in educational settings, as Hayes & Games (2008) make clear in their extensive literature review of design thinking in educational settings. The aim of the present article is to correct this lack by making a contribution to this neglected area of research.

Since game design thinking in educational settings is a new research area, we have to ensure that we are not confusing it with the use of games as vehicles for learning (Klopfer, 2008; Juel Larsen, 2012; Juel Larsen, 2015a). Serious games have been, and still are, hotly debated, as Ian Bogost clearly illustrates in *Persuasive Games* (2007). Nor does this article include reflections on learning programming to make computer games in an educational setting (Paige, Attridge & Brooke, 2006).

The main focus of this article is game design thinking in educational settings. It addresses questions like: How should we teach game design? How should we frame a huge topic like game design? Which elements in game design theory should be included and excluded? How can we encourage game design thinking? And finally how can we evaluate game design thinking? This article will attempt to answer those questions through our model of the expanded game design space.

This article is based on research conducted during our computer game design courses for undergraduate students. During the first years of running our courses, we did not manage to achieve the desired results either in the quality of student games or in the students' level of game design thinking. In evaluating the courses, we realised that we needed a clearer framing (Schön and Rain, 1994) of the game design assignment. This would ensure that students would not lose their footing in a field as broad as game design. Presented with such a challenge, we asked ourselves how we could frame the entire computer game design process in an easy and understandable way that would include evaluative guidelines. After considerable research, we developed the model of an expanded game design space. We discovered that this not only led to the creation of better games and to enhanced game design thinking; it also instilled in our students a level of critical learning about game design.

In the next section we will present our philosophy of learning, which highlights participation, reflection and construction, and our didactical approach, which outlines the background for our game design courses. We will also provide an overview of the expanded game design space, including a clarifying figure. The subsequent four sections

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unpack each layer of our model, while the final and concluding section summarizes our findings.

Philosophy of Learning

Our philosophy of learning is based on active participation, reflection and construction (Bateson, 2000; Schön, 1983; Majgaard, 2015; Majgaard, 2014; Majgaard, 2013; Papert 1990; Papert & Harel 1991). The students participate actively in the design process and develop prototypes in collaboration with user groups (Sharp, 2007). We promote a particular way of thinking in the design process in order to optimise and improve student design practice.

It should be noted that our understanding of learning has its basis in Scharmer (2000), Gee (2003) and Shaffer (2006), who all work with emerging learning or, as Scharmer puts it, 'not-yet-embodied knowledge' (p. 138), thereby emphasising the 'not-yet' realised as opposed to the later reproduced (Engeström 1986).

The paper presents primarily a theoretical contribution directed toward practice, based on reflective practice, student evaluations, and five years of conducting classes. The article contains illustrative examples from student games. Our goal has been to reflect on, develop and explore the learning of game design in a classroom setting. Student productions can be found at http://op.tek.sdu.dk/.

Our research contribution entails a model of the game design space through which students learn to think, act, value and feel in a particular way – namely as game designers.

Didactical Approach

Our game design course is organised by way of framing rather than through open-ended assignments like *Design a computer game!* Such an assignment often generates frustration and uneasiness. Framing on the other hand disposes of the early frustrating fuzziness in the development cycle (Ylirisku, Halttunen, Nuojua & Juustila, 2009). Generally we understand framing as a sense-making process (Schön & Rein, 1994). The students are therefore given a very clear game design assignment, which is to develop a 2D, asymmetrical, multiplayer, hotseat, competitive computer game, preferably with top-down view. The assignment should be understood as involving a framework consisting of particular elements, each of which has been carefully selected and thoroughly reflected upon.

We have selected *2D* to begin with because it removes camera position issues and presents designers with a clear sense of regulated game space. The *asymmetrical* element underscores our desire to explore and understand different game mechanics and to see how their choice and implementation demand game testing in order to be *balanced* out. In this way, game tests are made a priority in the game design process, and go beyond being mere exercises in bug and collision finding. When combining game balancing and *game testing,* we draw attention to their importance both as tools for game design thinking and as crucial aspects of the game design development process. We promote the use of game tests as instruments for reflecting upon the current state of the game design and as an opportunity to analyse the *relationship of formal game elements*.

The students' experience of success enables them to learn to add or subtract game elements in relation to *structuring player strategies and choices*. The *multiplayer* element of the assignment was chosen to eliminate the time-consuming programming of artificial intelligences (AIs). Although we do not disregard the use of AIs in games, we wanted to navigate students away from spending precious time getting involved in complex AI programming. The underlying rationale is that the opposing player (multiplayer) constitutes the best possible AI. The *hotseat* dimension, where two or more players share the same keyboard during game play, removes difficult network programming from the game design equation, thereby making it possible to draw even more attention to game design. It should be noted that we do not use the original definition of the concept of multiplayer hotseat. Instead of designing turn-based games, we inspire students to design real-time competitive games, with the proviso that they can make turn-based or co-operative games if they so wish. Playing at the same keyboard also opens avenues for exploring transgressive play. We have added a particular perspective to the assignment in order to filter out side-scrollers, since they inherently pose design difficulties in regard to proper usage of the upper half of the screen. This allows attention to be focused on understanding and using the entire game space or level (which can easily have other dimensions than that visible on the screen).

Our game design course runs over 12 weeks, eight hours a week in two 4-hour sessions. Students are asked to design a working game and write a final report. During the 4-hour sessions, we review and discuss different aspects of game design in relation to the assignment, and students complete associated exercises. In the first six sessions, groups of 4–5 students are formed. They get to know each other while developing a minimum of three different ideas and making a paper prototype. Presenting and providing feedback on the prototypes are performed as rolling playtest sessions, where groups get to see and try out other groups' game design ideas. Paper prototypes make it easier to select game ideas with the greatest potential. After working for two weeks with their three ideas, they select the one they wish to pursue. To control the development process, students create a design document consisting mostly of a backlog description of game idea and formal game elements, including 'need to have' and 'nice to have' aspects. They are instructed to organise the division of the workload in scrum-like (Takeuchi & Nonaka, 1986, Sutherland, 2004) routines, where different group members perform certain actions by specific dates. They are expected to meet up outside class at least once a week. Over the entire course, we hold as many game test sessions and presentations as we can. A minimum of three presentations (including three short papers (one page long) on selected game design topics) is held in class. At least five game test sessions are held, because initially students understand test groups as a bug-finding tool with discussions about collision and other programming issues. Over time, students begin to understand game tests as part of

the game design development process. They start to value the input they get as an extension of their own reflections and to understand how other players and fellow game designers view their game. The course ends with an oral examination, where they reflect on selected aspects of game design theory and discuss the development process in relation to their report.

We set up the entire game design space as a sandbox: a place where students can be playful, creative, innovative and where it is ok to make mistakes without fear of rejection (Gee, 2003; Majgaard, 2013). Bateson (2000) also describes a playful space (Juel Larsen, 2015b) as an opportunity to explore possibilities and outcomes without real-world consequences.

Overview of Expanded Game Design Space

This paragraph contains an abbreviated version of our model of the expanded game design space (see **Figure 1**).

The *first* layer addresses clear game design assignment, player experience and game mechanics.

The *second* layer constitutes game design thinking. Once our game design students have both articulated precisely what kind of player experience they wish to communicate *and* have designed the game mechanics accordingly, they are equipped with a powerful set of guidelines for game design thinking, all of which will support the rest of the game design development process. This layer contains six aspects of game design thinking (see **Figure 5**).

The *third* layer establishes correspondence between formal game elements and problem-based creativity. During our game design courses, we observed what we later termed 'problem-based creativity'. This concept stems from an understanding that design challenges look much like challenges in computer games. When regarding design challenges as mini-games, it becomes clear that, like games, they consist of a clear goal (solution), a challenge (what is the design problem), a conflict (how do we solve the design problem) and a variable outcome (there can be many solutions). Such an approach creates a particular, clear way of thinking about design challenges.

The *fourth* and final layer is evaluative and will be expanded in later sections. A strong correlation between clear game design assignments (framing), clear formulation of intended player experience, appropriate game mechanics, game design thinking, understanding problem-based creativity and evaluative guidelines constitutes the four interconnected layers that constitute our model of an expanded game design space (see **Figure 1**).

The following paragraphs unpack each layer with an emphasis on layer 2 – game design thinking.

Layer 1: Framing in the Game Design Space

The first layer in our concept of game design space addresses precise and considered *framing* of the game design assignment. Clear framing makes it easier to get a handle on the dazzling, new and highly complex topic of game design. It is also important for students to develop a clear sense of the kind of player experience they want their design to create. This aspect is player-centric and concurs with the notion that *player experience* is a crucial aspect of game design (Fullerton 2008, Schell 2008). However, as everybody in the field of game design knows, player experiences can encompass, or mean, many different things and it can be difficult for students to choose the experience they want their design to create. Our research does show, however, that successful game design rests on the articulation of a very precise description of the kind of experience designers wish to communicate through their game. The litmus test question to ascertain whether students have thought about player experience is: Give a short answer to the question *'What kind of experience do you wish you game to generate?'* The student group who designed *Oil Crisis* (http://op.tek.sdu.dk/) wanted to create a balanced game where

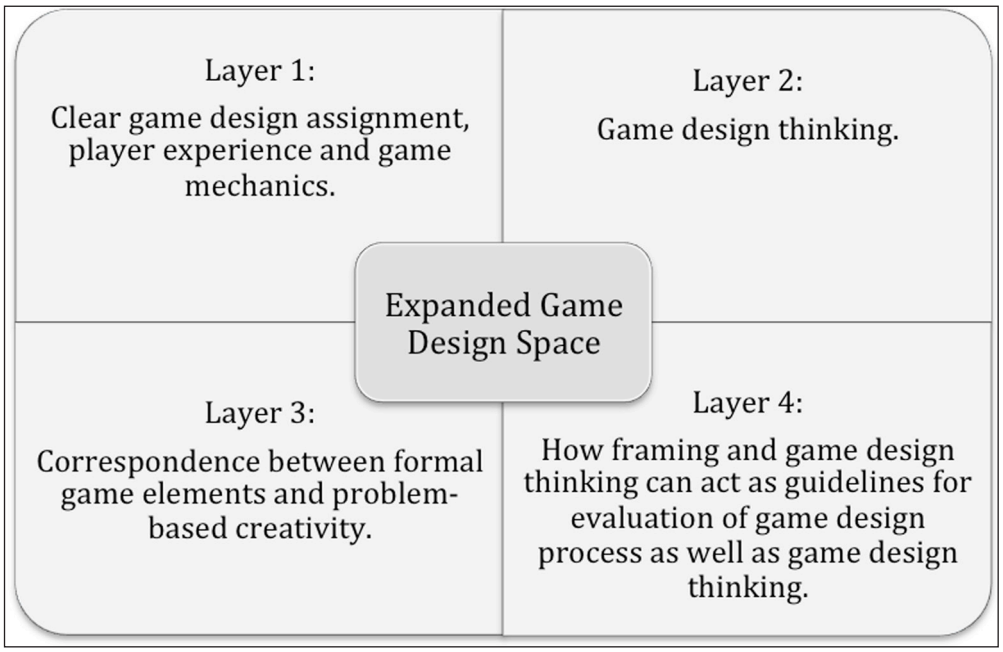

Figure 1: Expanded Game Design Space.

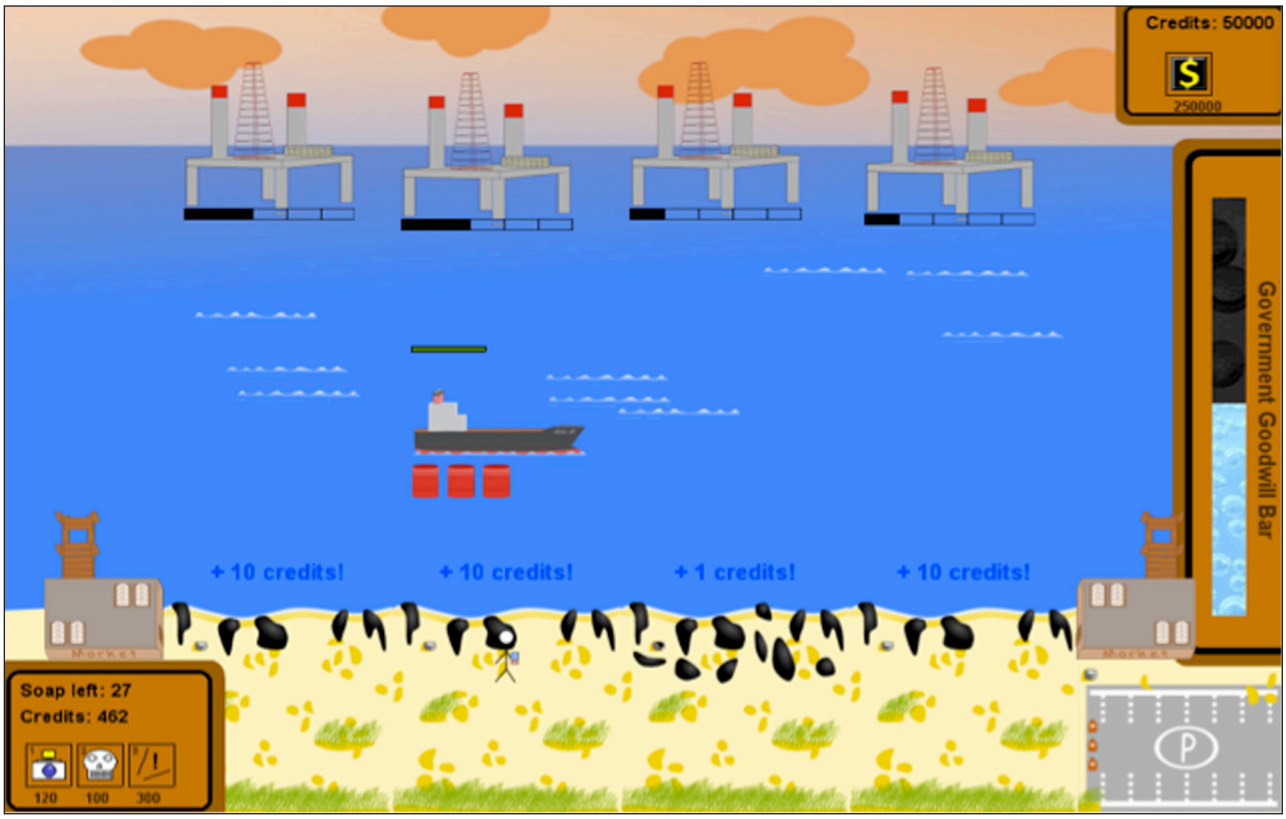

Figure 2: Screenshot of *Oil Crisis* (2014).

powerful oil-producing companies are pitted against the fragile environmental activist. Both parties fight to gain government goodwill, seen in the progress bar to the right. It is a game where large, slow forces fight the small and agile (see **Figure 2**).

Player experience and the description of game mechanics are closely related. Our understanding of game mechanics follows Miguel Sicart's (2008) definition. Sicart sees game mechanics as "methods invoked by agents for interacting with the game world" in relation to rules and challenges. He expands and clarifies his initial definition by correlating game mechanics with 'verbs' in sentences, describing game mechanics as *actions* players (agents/non-player characters) can take in game worlds. In first person shooter (FPS) games, players can shoot, jump, crouch and reload, and in massively multiplayer games (MMOGs), players can (among many other things) cast spells, teleport or become invisible (World of Warcraft, 2004) or dissolve their avatar only to become complete again, as is the case in *Skylanders* (2011). In *League of Legends* (2009) each champion can invoke a particular set of actions or methods when combatting opponents. All these actions constitute methods players can invoke when interacting in a game world. They are what we understand as game mechanics.

Clear framing, formulations of player experience and descriptions of game mechanics constitute the *first* layer in the framing of the development process.

Layer 2: Six Aspects of Game Design Thinking

Game design thinking is, in general, structured in relation to the design space associated with designing a particular game. Game design thinking is based on the most influential aspects of game design theory in *relation* to the framed assignment.

In our case, game design thinking is constructed from six different, yet closely interrelated, aspects of game design. The *first* aspect concerns formal game elements (Fullerton, 2008, Salen & Zimmerman, 2004). As many formal elements of the game should be listed as possible, in order to understand objects, their properties, behaviour and relationships. It is *very* important to grasp how difficult it is to predict how static formal game elements will act when put into motion. Such an insight is closely linked with game testing. Design thinking in the design space exhibits, therefore, a strong correlation with game testing, especially in conjunction with how objects and their properties and behaviour relate to each other during gameplay. Formal relationships should be fleshed out and closely investigated. From our experience, a close examination of these relationships constitutes a key aspect in game design thinking. Students are often surprised when they discover how relationships between objects, properties and behaviours are connected and how they shape a dynamic system. Once these relationships are properly understood, students develop a clearer understanding of system dynamics, and this leads to a unequivocal point of departure for further game development and game testing.

During this process, students do not only learn the importance of game testing; they also discover how to rigorously test each formal game object, its properties and behaviour and its relationship to other objects. This is all conducted in incremental steps, where each

object is clearly fleshed out and tested. For example, in *Oil Crisis*, player one has to shoot the soap dispenser in order to clean away oil spills and does so at a speed that matches the frequency of oil spills produced by oil rigs. In order to get a clear idea of how many times they need to shoot, players have to calculate the precise relationship between number of shots needed to clean the beach and the speed of oil spills produced. This demands rigorous game testing.

The *second* aspect concerns game balancing and finding more than one way to win (Sirlin, 2008) in order both to create meaningful choices (Salen & Zimmerman 2004) and generate strategic thinking (Crawford, 1982). Game balancing concerns the balancing of relationships in order that, in multiplayer games, both players have equally viable options and thereby both consider the game to be fair. Viable options are essentially player choices. They give players more than one real choice (Sirlin, 2008) and more than one way to reach the goal(s) (Crawford, 1982). Treated together, viable options and fairness generate strategic thinking, since players have to consider which strategy to pursue in order to achieve the desired goal. It is important (in multiplayer settings) that goal, choice and strategies are equitable, so that the opposing forces find the game just as easy or just as hard. Fairness and game mechanics are closely related; it is essential that neither player feel that there is a single overpowering move in place.

In order to flush out overpowering moves, Sirlin proposes an analytical model, which he calls *Yomi Layer 3*. It is a tool that detects imbalance and making it possible to properly balance moves between players in the game system. *Yomi Layer 3* is an investigation of the relationship between moves and counter-moves. If there is no move in place to counter an attack from the opponent, the move is overpowering. In order to strengthen strategic thinking, counter-moves should be designed. Sirlin expands his thinking and proposes another move to the counter-move, thereby introducing yet another counter-move. In other words, Sirlin proposes that a good move (player 1 attacks) should be followed by a counter-move (player 2 defends/attacks), followed by an attack/defence from the defender (player 2 now attacks/defends) and a defending/attacking move (player 1 now defends against player 2's attack).

A close analysis of this circle of moves between attack and defence makes it possible for designers to properly understand and balance their game. Once again, game testing is the key to flushing out overpowering moves or finding missing counter-moves, which in most cases generate feelings of unfairness – an indicator of uneven distribution of player choices that only serves to increase the risk of game rejection.

In *Oil Crisis*, it is important that the special move called 'oil crisis' is tough enough to stress the other player while at the same time leaving enough room for him/her to respond to the threat, so that 'oil crisis' does not constitute an overpowering move.

It is of particular importance to balance asymmetrical games, since players often deploy different game mechanics, strategies and/or goals. Single player game balancing has to do with objects and AIs and is less concerned with unevenly distributed choices and strategies.

The *third* aspect of game design that makes up our game design thinking focuses on reward structures (Yee, 2014; Juel Larsen, 2012; Hopson, 2001) and how to use them as an integral part of game design. Typically, reward structures, as Hopson clearly illustrates, are divided into ratios and intervals that can be both fixed and variable. Fixed ratios are related to rewards that appear according to a predictable timetable or after a specific player action. Fixed ratios are therefore predictable. Players can determine when a reward will appear and devise a strategy accordingly. Variable ratios are inherently unpredictable. Players are uncertain (Costikyan, 2013) as to when a reward will appear in the game or when it presents itself due to player activity. This provides game designers with a toolbox of predictability and uncertainty in relation to player choices. Should players choose one reward over another? Presenting players with different reward structures adds strategic complexity to the game, while at the same time it gives designers different ways to engage players and support continuation desire. Questions to be asked include: Should players be offered rewards on the basis of activity, time or perhaps even location in the game space?

Reward structures incentivise game designers to explore the distribution of rewards in relation to objects, choice and strategy, while at the same time making good use of the entire game space (Aarseth 2000); this is also known as level-design (Smith, Cha & Whitehead, 2008).

Rewards also constitute a good method of introducing imbalance in a measured way. This can be done by introducing random effects after a certain amount of time or after a specific action, effects that result in one player having a slight advantage over the other. Reward structures, therefore, present game designers with a very dynamic tool to utilise the game space, handle internal relationships between formal elements, and structure the game space (level-design/layout). Reward structures should be designed against the basis of a matrix of predictability and uncertainty. In *Oil Crisis*, players can earn a reward in form of credits by sailing barrels of oil from oilrigs to the market place. Credits can be utilised to put the other player under pressure by encouraging costly special moves. Reward structures and the system relation of formal game elements thereby operate hand-in-hand.

The *fourth* aspect of game design deals with game feel (Swink, 2009). It takes into consideration the development of a responsive and fluent game environment. Swink defines three building blocks of game feel. The *first* is *real-time control of virtual objects*. This deals with the interaction between player input and game response to ensure precise, continuous control in order to produce aesthetic player sensation. The *second* addresses *simulated space* and is concerned with the relationship and interaction between controllable objects (avatars) and objects of the game world. In this respect, simulated space underscores 'tactility' in the game world. How are the objects materially communicated? Are they heavy or light, easy or difficult to move around, hard or easy to kill? The overall question is: What sensation do game designers want to

distribute to players? The *third* building block of game feel is polish. Polish is closely connected with the *fifth* aspect – called juiciness (Juul, 2010; Jonasson & Purho, 2012). It deals with how relationships between controllable objects and the environment are communicated: Do objects slide over surfaces, crash into stuff or disappear into thin air? Do collisions produce particles? The same goes for avatar movement. Do particles appear when the characters walk or run? Does the game use camera shake when objects collide or in relation to pushbacks when they crash into each other? Are the graphics correlated with sound effects to underscore actions in the game world? When the fourth and fifth aspects are taken together, they deal with players' perception of the game's aesthetic fluency and movement and the 'tactility' or 'physicality' of objects in the game world (Swink, 2009).

Polish and juiciness present designers with options in their thinking about game design that go beyond listing formal elements, system dynamics and balancing values and behaviour. They are far from being merely about graphics, sounds or effects. They *communicate* all aspects or the entire content of the game. Without good communication, the player loses interest in the game.

In the case of *Oil Crisis*, highlighted numbers over the beaches reveal how many credits the player receives, but also – implicitly – how many shots are still needed to clean the beach, both of which are highly relevant during gameplay (see **Figure 3**).

An underlying characteristic of polish and juiciness is that 'more, bigger and upward' are good, while 'less, smaller and downward' are bad (Lakoff & Johnson, 2003). In *Oil Crisis* the progress bar on the right side of the screen

Figure 3: Different credits awarded compared to degree of pollution.

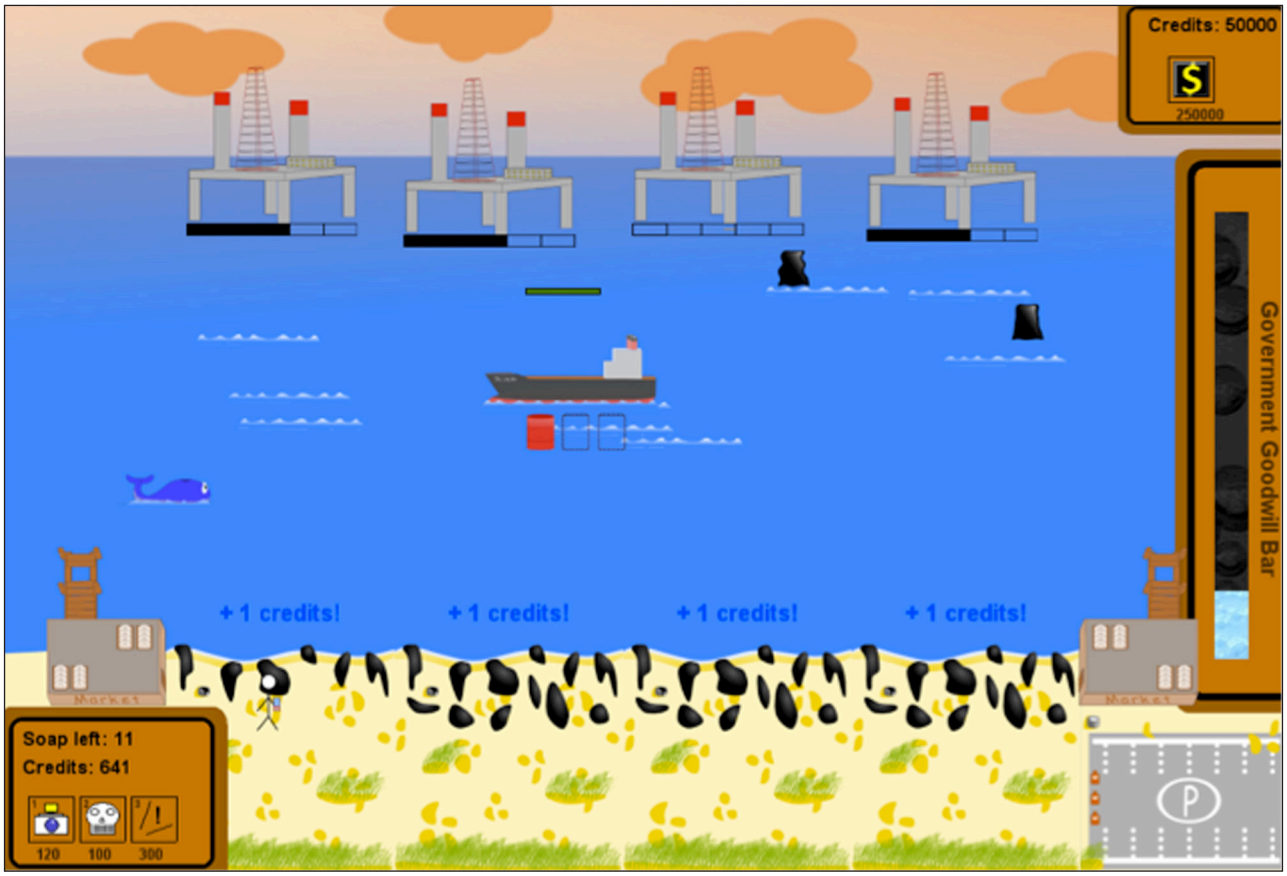

Figure 4: Illustrating the dark 'weight' of the oil pressing 'down' in the progress bar in the right side of the screen.

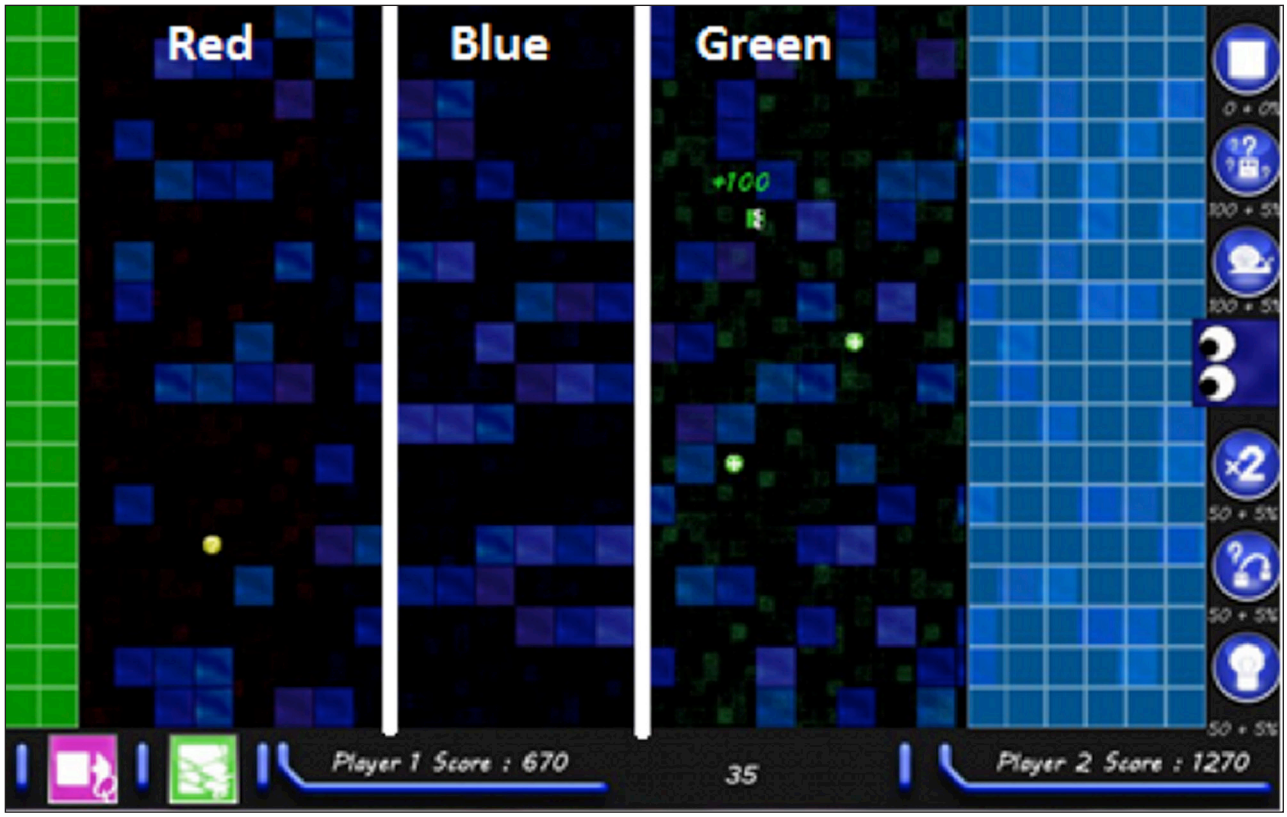

Figure 5: Little Green Box.

fills with soap (light blue) from the bottom up, indicating that the activist is progressing, while the oppressive power of the oil magnet (black) presses the soap down (see **Figure 4**).

The *sixth* and final aspect of game design thinking explores the concept of feedback (Adams, 2012). Feedback can be understood in four different ways. The first tells the players how close they are to achieving their goal(s), thereby stressing a relationship between the goal of the game and current player progress (McGonigal 2011). The second is concerned with amplifying game responses with polish/juiciness thereby promoting an understanding feedback as communication. The third way is concerned with accelerating or decelerating system dynamics. Positive and accelerating feedback is about entering an upward spiral, where it becomes easier and easier to score points and get ahead, leaving the opponent further and further behind. Negative feedback constitutes the opposite effect. It becomes harder and harder to get back in the game, since the downward spiral accelerates and becomes faster and faster, while the player loses more and more terrain. The fourth way is concerned with catch-up mechanics that gives players opportunities to win even when far behind (Elias, Garfield & Gutschera, 2012).

The first way of understanding feedback is closely linked with player progress in relation to game objectives, while the second way addresses game communication emphasised by polish or juiciness. The last two ways are strongly linked to game balancing and reward structures. It is important for students of game design to understand feedback both as communication (that games are really all about communication) and as systems that reinforce certain choices in order to drive players in particular directions.

In the game *Little Green Box* (http://op.tek.sdu.dk/), students embedded both accelerating and decelerating feedback. They split the game space into three sections. When player one is in the middle section (middle of the screen, blue background), neither player gets any points. When player one is in the left section (area to the left, red background), player two gets a point. Player one gets a point when playing in the green section (right side of the screen) (see **Figure 5**).

This not only creates a dynamic shift between competitive and co-operative play, but also makes sure that neither player enters a downward feedback spiral where it would become impossible to get back into the game.

Game design thinking	Aspect 1: Formal Game elements
	Aspect 2: Game balancing
	Aspect 3: Reward structures
	Aspect 4: Game feel
	Aspect 5: Juiciness
	Aspect 6: Feedback

Figure 6: Aspects of game design thinking.

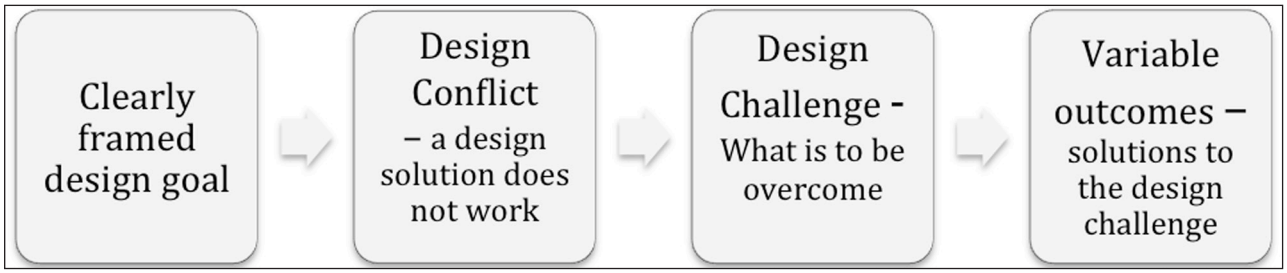

Figure 7: Problem-based creativity framed as a mini-game.

Taken together, these six aspects create a pedagogical overview for game design thinking (see **Figure 6**).

All six aspects constitute central areas of game design. Putting these six aspects together makes it easier and faster for students to grasp central and important aspects of game design that should be taken into account when designing games. In this way, these six aspects create spaces for game design thinking.

Layer 3: Problem-Based Creativity in the Expanded Game Design Space

The notion of problem-based creativity derives from insights into the benefits of proper framing. One of the most important insights is that the framing of design questions can be compared with the challenges met in playing a game. We discovered that, when tightly framed, design challenges produce creative solutions. Those observations led us to consider that meeting framed design challenges could be regarded as playing a mini-game. Their formal layout consists of the formal game elements. Like games, are they dependent on *goals* (frame), *challenges* (what needs to be overcome), *conflict* (how to overcome challenge/opposition) and the *participation* of one or more players. Regarded in this way, design challenges can be handled like challenges in games.

Design challenge benefits from being clearly stated, i.e. from having a clear design goal – which, in reality, is all about finding a new and better solution. They spring from *conflict* (e.g. if a design solution does not work, it produces a conflict either between game elements, with regard to interaction design, or between students). Such a condition creates a *challenge* to be overcome. Overcoming such a challenge is not simple. It often has variable outcomes, just like games. There is always more than one solution to a particular design challenge. Design challenges benefit from having more than one participant (player) working on the problem, just like when several players play a game (see **Figure 7**).

It should be noted that our understanding of computer games is in line with Bernard Suits (1978), McGonigal (2012), Fullerton (2008), Schell (2008), Costikyan (1994), Juul (2003), Salen and Zimmermann (2004) and Burgun (2013). Particularly compelling is the emphasis given by Burgun and Costikyan to the fact that games rely on *decision-making*, as opposed to the understanding of games in much boarder and looser terms – merely as interactive experiences.

To briefly sum up: the formal structures of problem-based creativity in the design space can be compared to a mini-game. There is a challenge with a conflict in relation to a solution among a set of participants (players) with variable outcomes (different solutions). Finally, both computer games and problem-based creativity are governed by rules.

Stating design challenges in this way makes them fun to play (overcome). Students instantly relate to design challenges as mini-games. Reframing game design challenges as creative mini-games produces often surprising and innovative outcomes to otherwise complex problems.

Layer 4: Evaluating Outcome of Design Thinking in the Design Space

One of the many difficulties in game design has to do with the evaluation of ideas and of the outcomes of game design thinking or problem-based creativity during the design process. If a clearly framed point of departure for the game design process is established, students can evaluate their ideas, their design thinking, and their design solutions in relation to the initial game design assignment. It should be pointed out that framing guides idea generation along with thinking in the design space, and in relation to the outcome of the problem-based creativity. This only underlines the importance of ensuring that the framing of the assignment is precise. It brings the framing of the game design assignment to the forefront in the entire game design process.

Clear framing, therefore, serves to: (1) establish a point of departure for the game design process, (2) act as a guideline for ideas and game design thinking, (3) help frame challenges for the problem-based creativity mini-games, and (4) act as an evaluating tool for ideas and the outcome of design thinking and problem-based creativity.

Summary and Conclusions

In this article, we have presented a model of expanded game design space. It is based on research that was conducted as a parallel activity alongside running game design courses at the University of Southern Denmark. Applying our model of expanded game design space meets a two-fold aim. The first is to present a clear and straightforward overview of the components of the game design process. The second is to ensure that students learn to think, act and feel like game designers.

In order to fulfil these objectives, four separate, yet interconnected, layers are needed. The *first* layer addresses clear framing as a pivotal element in teaching game design. It rests on a player-centric approach (i.e. on designing player experiences) combined with game mechanics. The *second* layer revolves around game design thinking constructed from six essential aspects: formal game elements, game

balancing, reward structures, game feel, juiciness and feedback. These aspects should be adjusted according to the game design assignment. If the assignment revolves around designing story-based adventure games, for example, some of the aspects should be adjusted accordingly. The *third* layer relates to the practice of solving design challenges during the design process. We have discovered how design challenges in the development process can be creatively addressed by applying the same problem-solving techniques used when playing mini-games. The *fourth* layer returns to framing, but this time using it as a guideline for evaluating the outcome of proposed ideas and game design thinking, and for measuring creative solutions.

Our model of expanded design space has proved to provide an easy way to understand and structure game design processes from beginning to end. Beyond that, it encapsulates the essential elements of the game design development cycle in an educational setting, allowing students to function both as learners and as game designers.

Competing Interests

The authors declare that they have no competing interests.

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How to cite this article: Larsen, L. J., & Majgaard, G. (2016). Expanding the Game Design Space – Teaching Computer Game Design in Higher Education. *Designs for Learning*, 8(1), 13–22, DOI: http://dx.doi.org/10.16993/dfl.68

Submitted: 07 January 2016 **Accepted:** 07 January 2016 **Published:** 29 January 2016

Designs for Learning is a peer-reviewed open access journal published by Stockholm University Press.

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