Refining Research in Gameful Design

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Abstract. Transforming daily chores into game-like activities has long been a tantalizing promise. Whether it is completing homework, washing dishes, or even filing taxes, many of these tasks have been incorporated into serious games or gamified interventions. Yet, the question remains: why do such efforts often fall short, leaving mundane tasks as unappealing as ever? In this article, we argue that the literature on game interventions could benefit from a methodological shift to better understand the impact of game mechanics on human psychology. We illustrate this point by presenting two experimental protocols that isolate game elements, providing a clearer understanding of their effects on the desired outcomes. The results of both studies are not disclosed here, as our focus is solely on the protocols themselves.

Keywords: Gamification · Serious game · Game elements · Methodology

1 An Overview of Game Use in Scientific Research

1.1 A Brief History of Games in Research

Since the beginning of games, playing certain games like chess or Chaturanga may have been part of military tactics training and education [1]. Even the best-seller Monopoly derives from the Landlord game, actually designed to educate players about the market economy and the risks of monopolies [2].

So there is nothing new in the idea of using games for more serious purposes. Knowing this, there is not much surprise in the fact that "serious games" - games which purpose is other than plain entertainment - were the first types of game to appear in scientific studies. By the late 1950's, war games and business games, which are more or less simulations of real life situations on paper, appear to have gained some popularity for training [3]. As a result, some scientific studies start to emerge, discussing the design choices of a specific training simulation [4] or using these simulations as a tool to study human behavior [5]. The term simulation is interestingly sometimes even used as a synonym for "game" [6].

Meanwhile, computer science is starting to develop, and the first video games appear in literature around the same time as illustrations of technological prowesses. Such as the demonstration of AI power by having a computer play an

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entire game of chess in 1958 [7]. Eventually, these computer tools are combined with the aforementioned war and business simulation games and give rise to the first digital serious games, like HUTSPIEL [3].

As computer technology became more powerful and more easily available, interventions using serious video games became less expensive and complicated to conduct.

Trying to make sense of what actually makes a game fun, Malone among others, conducted a series of experiments which are to our knowledge the first that focus specifically on the effect of individual game elements or mechanics in a video game intervention, rather than considering the game as a whole. He stripped all elements that could make a game enjoyable and added them back one by one along different experimental conditions [8]. That way he was able to produce guidelines on what he had determined to be important factors to create fun: challenge, curiosity and fantasy [9].

This focus on game elements detached from the actual game, could be considered as the first steps of gamification. As digital technology became more and more part of people's daily lives, gamification started to appear on websites and early social media. The Foursquare app was probably the introduction to gamification for many, as the 2009 app awarded points and badges to its users based on where and when they logged in the app [10]. The concept and the actual term "gamification" both gained steam around this time, with the term "gamification" appearing on the Gartner Hype Cycle chart of Emerging Technologies in 2011, certifying its place in the space and overinflated expectations [10].

As "gamification" is a term that originated in the industry, its relevance in the research space did come into question, especially in comparison with well established game-related words like "serious game" and "gameful design". [11] rigorously argued the relevance of the term and provided a definition for it that is still used as a reference in the field: gamification is the use of game elements in non-game contexts.

1.2 Landscape of the Research Nowadays

Gamification and serious games are indeed different concepts but are closely related, which can clearly be seen in the fields they are applied to. According to recent reviews of the literature [12,13], one of the main fields for both concepts is education and training, spanning across many disciplines and fields of study. Healthcare, sustainability and business and economics are also popular fields in which gamification and serious games are used.

Research on game-based interventions usually involves creating a substantially developed game to target a specific outcome and evaluating its success in achieving it, rather than examining the role of individual game features [14]. This approach has the advantage of taking into account the synergistic impact that multiple game elements can have as a whole. These interventions also mainly conducted outside lab settings [14] which helps measuring the ecological impact of such interventions [15].

However, this approach does have some drawbacks such an insufficient understanding of the underlying mechanisms supposed to be triggered by game-based interventions or the inability to identify the individual impact or relevance of specific game elements [16,17]. A complementary approach would be to conduct studies focusing on individual game elements and their impact on specific outcomes. Focusing on individual game elements chosen for the psychological mechanism they are believed to trigger would help confirm their effects and provide a clearer understanding of the potential advantages and disadvantages of each element.We believe that game-based interventions would benefit from design recommendations stemming from studies on individual game elements. One might use [18] study on achievements and choose to add a few achievements to their own serious game in an attempt to improve time-on-task rather than intrinsic motivation. Similarly, one might choose to add points to their game in order to boost player's performance, according to [19]. Regarding the effects of combined game elements, [20] highlighted that while feedback and progress bars individually increase task perseverance, using them together has an even greater effect. These studies bring valuable insight on the mechanisms of specific game elements and can work as building blocks to design future experiments. However this type of study remains quite scarce in today's literature. This article aims to illustrate and advocate for this type of study design to enrich the scientific literature on game-based interventions. Studies in this field often have short timeframes, making it difficult to account for the novelty effect or examine long-term impacts, such as motivation to learn [16,21].

In the following sections of this article, we present two of our experiments currently being published. Both research were conducted in compliance with ethical standards and approved by institutional review board (for the first) and ethics committee (for the second). These presentations focus on context and methodology to serve as examples of research targeting mechanics on an individual basis. The results are not the subject of this paper.

2 Case Study 1: Large Scale Online Gamification Experiment

2.1 Introduction

In this study, we chose to focus on points-the most emblematic game element used in gamification-and their impact on intrinsic motivation. Motivation is indeed often mentioned as a potential benefit stemming from gameful design [11]. Based on Deci and Ryan's Self-Determination Theory, intrinsic motivation refers to engaging in an activity for its inherent enjoyment or personal satisfaction, while extrinsic motivation involves performing a task to attain external rewards or avoid punishment. Improving intrinsic motivation is generally preferred, as it is believed to lead to more lasting and self-sustained engagement [22]. We aimed to develop an experimental protocol featuring a gamified task that would enable a clear comparison between self-assessed intrinsic motivation scores, spontaneous replay, and the presence of a point system within the task.

2.2 Drafting the Protocol

Based on previous research in the domain of game elements and intrinsic motivation, it appeared likely that the effect size that was to be measured in this experiment would be rather small [19]. Using a priori statistics, we computed an estimated size of participants required to reach significance in our results and made protocol choices accordingly. Given that the intervention would require several hundred participants, we opted to conduct an online experiment. This approach minimized logistical demands for each participant and allowed for broader dissemination. For the same reasons, we decided to keep the intervention as short as possible in order to decrease attrition and, once more, make it easily spreadable. The task chosen to be gamified was a color matching task. Circles, either colored in yellow or blue, would appear on the screen and move up, like helium balloons. While ascending, participants would be able to direct the circle either to the left or right side of the screen using a rotating funnel-like tunnel controlled by arrow buttons. On the top left side of the screen was a yellow bin and on the top right side a blue one (see Fig. 1). Research suggests that humans over the age of four naturally sort items by similarity [23], so we anticipated that participants would instinctively place circles into the corresponding color-matching bins, even without explicit instructions. Playtesting confirmed this behavior, eliminating the need for a detailed task explanation and mitigating the risk of misunderstanding.

This task also provided a flexible foundation for adding or removing various game elements as needed for the experiment.

2.3 The Experimental Conditions

Our initial goal was to analyse the impact of a score or point system on the intrinsic motivation to do the sorting task. At first, only two experimental conditions may appear necessary: one condition including the colored circles and bins (C1), and another adding a point system with a displayed score increasing by 1 every time a circle is correctly matched to a bin (C2) (see Table 1).

According to the MDA (Mechanics-Dynamics-Aesthetics) framework [24], we identified the primary Mechanic of our task as the 'point system' alongside the 'color-matching mechanic.' The Dynamics might involve optimizing the tunnel's rotation or focusing on color information, while the Aesthetics could be related to Sensation (the intrinsic pleasure of color-matching [25]) or Challenge (the dexterity required to sort objects). Aesthetics are linked to "fun" which is usually considered closely related to the idea of motivation, either intrinsic or extrinsic [26]. To control for the impact of the aesthetics of Sensation, we introduced a condition where the bin colors mismatched the circles (C0). This resulted in three initial conditions: mismatched bins and circles (C0), matching bins and circles (C1), and matching bins with a point system (C2).

Fig. 1. Screen capture of the experiment.

On closer examination, we noted that the point system provided not only numerical progress tracking but also positive feedback, as the score would increase by one point each time a circle was correctly matched to its corresponding bin. Feedback is a known pillar of motivation according to flow theory [27], so the effects of progression tracking and task feedback are inextricably linked when using a point system. To isolate these effects, we added a condition (C3) using non-numerical positive feedback: a smiling green emoticon displayed briefly on a bin after each correct match. We also included a combined condition (C4) with both the point system and non-numerical feedback to test for redundancy, hypothesizing that the combined condition would yield similar results to the point system alone.

Flow theory also emphasizes goal-setting and clear objectives. The point system in C2 provided a sense of progression but lacked a defined goal beyond achieving the highest possible score, which is usually considered not an effective way of setting goals 26. In order to study the impact of this effect, we decided to add an experimental condition with an alternative point system (C5). In this condition, the score will be displayed as a percentage of correct circle matches out of the total number of circles sorted at that time. Players would all start with a 0% correct match score, then jump to a 100% correct match score if they matched correctly the first circle. If they correctly matched the second circle their score would remain at a 100%, however it would go down to 50% of correct matches if they mismatched their second circle. This system could implicitly encourage maintaining or achieving a perfect score. A final condition (C6) combined this percentage-based point system with the positive feedback from C3.

To sum up, this study has two inter-group independent variables:

- **Point system** (no points, standard, or percentage), where we hypothesize that both standard and percentage-based systems enhance intrinsic motivation compared to no points. And that percentage-based systems increase intrinsic motivation more than standard points thanks to goal setting mechanisms.
- **Visual feedback** (on vs. off), where we assume that enabling a visual feedback will enhance intrinsic motivation if not combined with a score, compared to no visual feedback. However we assume that enabling a visual feedback combined with a point system will have no effect compared to the condition with the point system alone.

The seven experimental conditions are (see Table 1):

- **C0**: Mismatched bins and circles.
- **C1**: Matching bins without points.
- **C2**: Matching bins with a standard point system.
- **C3**: Matching bins with positive visual feedback.
- **C4**: Matching bins with standard points and visual feedback combined.
- **C5**: Matching bins with a percentage-based point system.
- **C6**: Matching bins with the percentage-based system and visual feedback combined.

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Conditions	**Description**	**Visual**
C1	Matching colored circles and bins	
C2	C1 + point system with score increasing of 1 for every correct match	
C3	C1 + non-numerical positive visual feedback	

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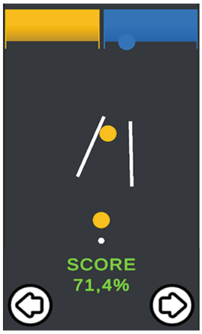
Conditions	Description	Visual
C4	C2 + C3	
C5	C1 + point system with score indicating the percentage of correct matches out of every match done until then	
C6	C5 + C3	

2.4 Quick Description of the Protocol

The experiment was conducted using a Unity web app with WebGL and hosted on a Firebase server. Participants could join the experiment simply by accessing the experiment's website. After reading the information letter and filling out a socio-demographic questionnaire they would be presented with one of the 7 experimental conditions of the sorting task. The circles would appear in 4 salvos in order for participants to get the opportunity to glance at their score during the experiment if one was displayed. Conducting the task would last for 1 min.

2.5 Strict Isolation of Game Elements/Mechanics

In order to measure the variations in intrinsic motivation between the different conditions, participants would then fill out 3 of the IMI subscales regarding the enjoyment of the task, their perceived capacity in doing the task, and the effort they put in. After filling in the IMI questionnaire, participants would be asked if they wanted to do the task once more. Based on their answer, the participant would either start another 1 min of the sorting task in the same condition they experienced previously then be directed to the thanking page, or would directly be directed to the thanking page. The goal of this replay question is to gauge whether participants are motivated to redo the task when given the opportunity but no incentive to do it. Their behaviour should give us an indication of their intrinsic motivation to do the task, reminiscent of [28] experiment in which participants were left in the room with the experimental device after the experiment was presented to them as over, in order to see if they would turn back to the experimental device on their own.

3 Case Study 2: Ecological Serious Board Game to Teach Ergonomics

3.1 Introduction

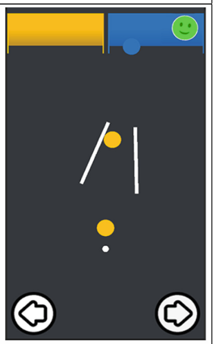
The study presented above addresses the issue of evaluating the impact of each gamification mechanism individually on intrinsic motivation. The second study presented here focuses on identifying the underlying cognitive mechanisms involved in the effectiveness of play. An educational game will be examined,

Table 1. .

Conditions	Description	Visual
C0	Mismatching colored circles and bins	

(*continued*)

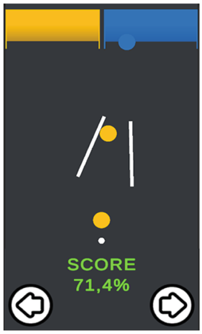
Table 1. (*continued*)

Conditions	Description	Visual
C1	Matching colored circles and bins	
C2	C1 + point system with score increasing of 1 for every correct match	
C3	C1 + non-numerical positive visual feedback	

(*continued*)

with specific hypotheses being proposed and tested regarding the effects of game

Table 1. (*continued*)

Conditions	Description	Visual
C4	C2 + C3	
C5	C1 + point system with score indicating the percentage of correct matches out of every match done until then	
C6	C5 + C3	

mechanics on learning processes. Furthermore, although designed for an experimental study focused on game mechanics, this educational game is conceived in a real-life context, as it is used in classroom situations by teachers. Such an approach aims for more generalized conclusions by identifying which specific elements of serious games contribute to improved learning outcomes. Why do some educational games improve learning outcomes while others do not?

To make progress in understanding this, we must compare different versions of games while testing specific hypotheses about the factors that influence whether users learn from them. For instance, in a card game where educational content is included on the cards, but reading and understanding this content is not essential for winning the game, the game designer could hypothesize that players may experience incidental learning-where mere exposure to the content leads to learning. However, we might reasonably doubt this assumption, as it could explain why educational games often lead to low learning outcomes [21]. In contrast, generative learning represents the opposite of incidental learning: through the game's rules, players are required to understand the content to succeed. This implies that the game involves an activity grounded in comprehending the educational content, making understanding a prerequisite to winning. Our study aims to leverage these insights by designing game mechanics that activate these cognitive processes, thereby enhancing the educational impact of the game. Alongside questions regarding learning outcomes, another issue would be why some games generate higher levels of interest than others. The relationship between game mechanics, interest, and learning outcomes is a key focus of this study. [29] emphasized the importance of social presence in enhancing learner satisfaction. [30] suggests that multi-user can increase interest through competition of cooperation, but without making comparisons all things being equal. This presumably positive impact of the group on interest in educational games often recurs in the literature, as mentioned by [21] in their systematic review, although never formally demonstrated.

3.2 Drafting the Protocol

In essence, our study seeks to advance the understanding of educational games by systematically varying game mechanics and examining their effects on learning and motivation. Through this approach, we hope not to validate our game, but to contribute to the development of more effective game-based learning tools. A generic version of the game has been designed by researchers and teachers. This game called "Innovation Island" was designed for engineering school courses, and several versions have been modified for the experiment. Its aim is to introduce students to the principles of Design Thinking (DT) in a fun way. The game presents the conduct of an innovation project as a sailing voyage, with uncertainties, a degree of randomness, but also methodical ways of achieving success. The player(s) receives an initial hand of five cards drawn from a shuffled deck. The player(s) plays a card each turn, representing a design action, to move their ships forward on the board. The arrival of the ships at the islands containing the treasure chests represents the achievement of the design objectives (see Fig. 2).

3.3 The Experimental Conditions

In this experimental study, we aim to understand precisely what are the processes that can make an educational game efficient for learning and favoring interest for the content. To test this, we have two inter-group independent variables with two modalities each:

- **Type of learning** (incidental vs. generative learning), we hypothesize that generative learning improves memorization and comprehension.
- **Number of players** (one player vs. 3 players), we assume that the game generates more interest with three players than with one.

Regarding learning type, the version of the game we call "incidental learning" has no mechanics that require players to learn content to win the game. They are exposed to all the pedagogical content, as in all the experimental conditions (the method descriptions on the cards), but they don't really need to read these cards to win. In the "generative learning" condition, on the other hand, participants have to indicate which DT step each card refers to, which means they have to read the cards in their entirety to understand them. We therefore have a total of 4 experimental conditions with hypotheses for each (see Fig. 3).

3.4 Quick Rundown of the Experiment

The participants were in a real classroom situation, with their usual teacher and the experimenter, and were each assigned to one of the 4 experimental conditions. Game boards were distributed and participants played a game. The experimenter was present to answer questions about the rules. After the game, which lasted around 45 min, participants answered a series of questionnaires.

3.5 Measurements

A priori knowledge questionnaire was filled in first. This questionnaire asks to what extent they ever had courses about DT, to control the group equivalence. Immediately after playing, the participants completed the interest, memorization and understanding questionnaires.

Memorization of tools and methods (micro content): participants had to complete 8 questions about specific elements related to design tools presented on the cards. For instance "What is the name of the data collection method that consists of being guided in real time as we perform an individual's target task?≫

Understanding of DT steps: four questions have been designed to assess participants' understanding of key DT steps. For instance "Which Design Thinking stage represents the transition from working with users to working on the product/service?≫.

Interest measurement: three items evaluating the degree to which participants are interested in the subject matter covered in the learning session (example: "I really want to learn more about Design Thinking"), and the pleasure related to the activity (example: "I really enjoyed this activity").

The protocols proposed here illustrate two ways studies can be designed to assess individual mechanics with a clear focus on the psychological processes underlying interest and learning. Moreover, as the second protocol demonstrates,

Fig. 2. Picture of the board game.

Interest Learning performance	Incident learning	Generative learning
Individual	+ +	+ ++
Collective	++ +	++ ++

Fig. 3. Picture of the board game.

they are also adaptable for use in real-life classroom settings. This shows that choosing an ecological setting for an experiment does not rule out the possibility of focusing on individual game elements.

4 Recommendations on How to Draft a Protocol to Study Individual Game Elements

Like many authors in the field, we believe that conducting studies that focus on specific game elements and their impact on precise measurement will be an addition of great value to the existing literature.

To choose what game elements to study, we would recommend one of two approaches: either identifying a psychological mechanism to trigger in participants and choose a game element to study that should impact this psychological mechanism based on theory then design a protocol to test it, or choosing a well-known game element that is claimed to impact the user via a specific psychological mechanism then design a protocol to verify it. This article's case study 1 corresponds to the latter, and case study 2 to the prior.

To conduct such experiments we recommend using simple experimental design. Specifically, one experimental group should be used for each game element under investigation, with comparisons made to a control group. The control group should differ from each experimental group by only one factor: the game element being tested. Depending on the approach, the control group may either include no game elements-representing a fully isolated condition to avoid bias due to possible interaction effects-or a set of game elements shared across all conditions, allowing for a more ecological approach. Experimental groups combining several game elements could be added to the protocol but should not replace one of the isolated elements-groups in case of experimental difficulties such as insufficient number of participants. When combining game elements in a single experimental condition, we recommend selecting them based on their theoretical synergy and compatibility. Studying the combination of game elements that are a priori incompatible may indeed be interesting as exploratory work, however it may result in negative results. This concern extends beyond exploratory research, as the fear of negative outcomes may discourage researchers from examining individual game elements in depth. However we believe that understanding the mechanics of game elements still has a long way to go and that negative results could be quite valuable. Repeating a lack of impact of a game element on several measurable outcomes could be an efficient way to highlight the value and relevance of a negative result. Thus, we encourage authors to closely examine any type of game element and their effect on all sorts of measurable outcomes.

One of the main objectives of scientific research is to enrich the existing literature. In the game-intervention field, a particularly relevant approach is to conduct studies comparing the impact of specific game mechanics, many of which remain unexplored. Complementing overall evaluations of entire games, this approach makes it possible to isolate the effects of individual components and refine our understanding of their role, thereby contributing to the advancement of knowledge in this field.

5 Discussion and Conclusion

After decades of research in game-based intervention focused on validating the impact of custom-made games on specific metrics, we observe a need to shift to a smaller lens. By studying the impact of individual game elements and mechanics we can foster the development of broader and more generalizable knowledge in the field.

We need to deepen our understanding of the effects of game mechanics and the cognitive and motivational mechanisms underlying them, which should ultimately lead to more concrete design recommendations for future experiments. In the long term, this improved knowledge will enable us to make better use of resources by designing more effective serious games and game-based interventions.

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