The Creativity Game: A Game for Teaching First Steps of Theoretical Creativity

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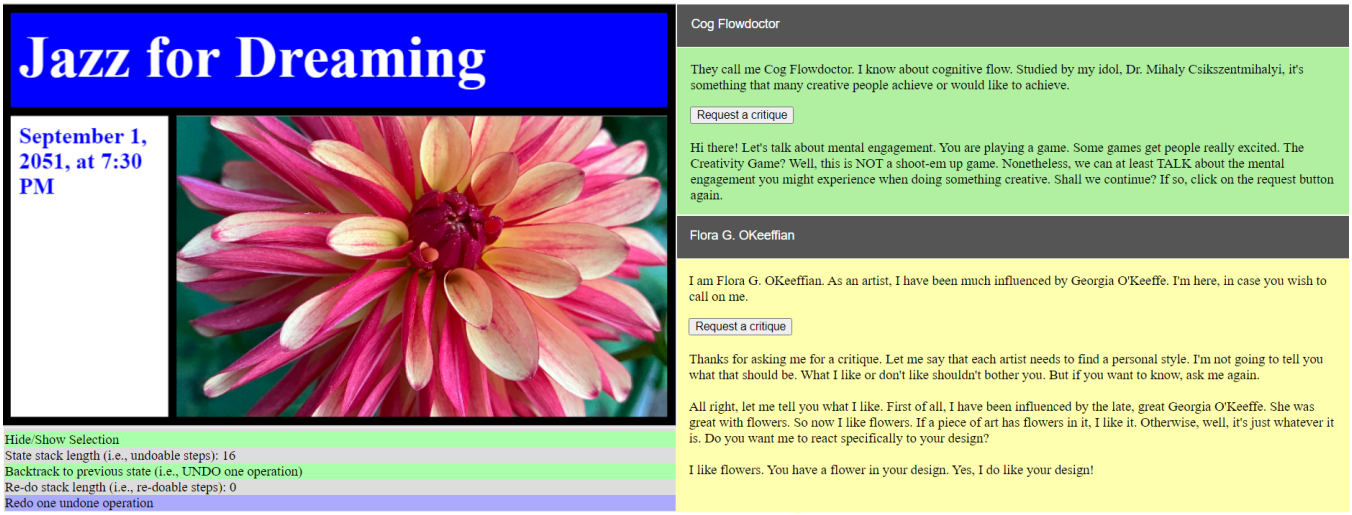

Figure 1: A screenshot of The Creativity Game in which a poster design is at an intermediate state of completion. Sample critiques are shown on the right.

ABSTRACT

Creativity is often highlighted as one of the most relevant competencies or skills of the 21st century. Teaching about theoretical underpinnings of creativity has therefore become relevant in numerous fields, from computer science to business management. If we consider creativity as a literacy, like writing or programming, it is important that people from different backgrounds can learn about the basic creativity concepts and how these might be manifested in practice. This article presents the design rationale of The Creativity Game, a simple online game intended to teach the player about some of the very basic properties or concepts in creativity theory: exploration, value, novelty, constraints, and transformation. The Creativity Game is a prototype presented here to spark conversation about how we teach creativity theory in a tangible way.

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C&C '23, June 19–21, 2023, Virtual Event, USA
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ACM ISBN 979-8-4007-0180-1/23/06.
https://doi.org/10.1145/3591196.3596826

CCS CONCEPTS

• **Human-centered computing** → **Interaction design**; • **Social and professional topics** → **Computing education**; **Computational thinking**; *Cultural characteristics*; *Intellectual property*;

KEYWORDS

creativity, game, creativity game, creativity theory, educational game, state-space search, graphic design, Boden, Czikszentmihalyi, novelty measure, value measure, aesthetic measure

ACM Reference Format:
Steven L. Tanimoto and Nanna Inie. 2023. The Creativity Game: A Game for Teaching First Steps of Theoretical Creativity. In *Creativity and Cognition (C&C '23), June 19–21, 2023, Virtual Event, USA.* ACM, New York, NY, USA, 8 pages. https://doi.org/10.1145/3591196.3596826

1 INTRODUCTION

Creativity is often described as one of the main components of 21st century skills [8, 13]. Yet, teaching creativity is not a straightforward task. Some of the main challenges are conceptualizing creativity [3, 7], and the difficulty designing assessment strategies that can reliably assess creativity [7]. Different methods for promoting students' creativity in formal education have included broader initiatives such as promoting curiosity and divergent thinking, encouraging multiple perspectives, and teaching convergent as well

as divergent thinking [6] – approaches which are all embedded into more generalized teaching philosophies, rather than focused on the pillars of theoretical creativity.

One of the potential avenues that some research has begun to explore is using digital *games* for teaching and assessing creativity [10, 11]. Very few evidence-based investigations of this strategy exist in current literature, and this paper presents a first step towards such a study.

This paper describes the overall design of a new game that is intended for use in exploring and teaching about the theory of creativity. The objective of the game is to design a poster for a music event, given some external constraints. The poster is "judged" by art critics (which are implemented algorithmically), who provide feedback based on the poster's novelty and originality, as well as how well the player has explored the possible conceptual space.

As of submission time, the game has been partially implemented as a web application.

The Creativity Game has three aims:

- operationalize theories of creativity using a kind of 'universal framework' onto which constraints and options can be brought to bear;
- investigate new means of teaching about creativity through a combination of creativity theory and design practice;
- provide a testbed for research.

The universal framework is a specific technical implementation of the classical state-space representation of problems and their solution options consistent with the description by Newell and Simon[9]. By operationalizing notions of *exploration*, *value*, *novelty*, *constraints* and *transformation* of conceptual spaces, we facilitate the clarification of standing theories of creativity in alternative ways.

The teaching of theoretical creativity has had the benefit of many wonderful articles and books (especially by Boden[1] and Czikszentmihalyi[5]), as well as a number of computer tools for creative practice in specific domains such as art, architecture, music composition and movie creation. The Creativity Game has the potential to provide experiences that help students connect theory and practice by integrating a creativity-support tool with educational material about creativity theory. We hope the game might find a role in teaching and assessing what is considered a 21st century educational need[8, 13].

The game may serve as a testbed for research in several ways. As a platform in which educational material can be embedded, it can support experiments that test the effects of alternative materials such as simulated critics that provide encouragement, criticism, or entertainment within the context of a creative project. It can also help support alternative formulations of conceptual spaces, for example by working with alternative tool sets, explicit constraints on allowable actions and states, and means of transforming the player's conceptual space through the introduction of new tools mid-session.

Creativity has a new importance in education because students need ways of thinking about their relationships to new generative AI agents such as DALL.E 2, Stable Diffusion, Copilot and ChatGPT. Thus the second aim of the project has a new timeliness and might be of greater importance to society as a whole than the other two aims which might be more of interest to only educators and researchers.

2 INTRODUCTION TO THE CREATIVITY GAME DESIGN

This section describes the game from two points of view: the player's typical experience and the overall design of the game.

2.1 The Player's Experience

The game is intended to be played by one person per play-through, in a browser connected to the internet. The game starts with a blank rectangle representing the space in which a graphical poster is to be designed.

The player is expected to spend roughly 10 to 20 minutes designing a poster using a set of provided menu options, such that the poster describes a particular fictional music event that would raise funds for a non-profit organization. Menu options provide means for subdividing the rectangular space into smaller regions and adding images and text to the regions. There are options for styling the content. A screen shot illustrating some of the options, in the context of an early-stage design in the game is shown in Fig. 2.

2.1.1 Critiques. During the game, the player has the option to request critiques of the design so far. The critiques are provided algorithmically by the game software and presented in a way that caricatures art critics or other imaginary critics. However, these critiques are produced in a manner intended to stimulate metacognitive reflection as well as thinking about what creativity could mean in the context of a design exercise. Some of the critiques include numerical measures and narratives that derive from the player's activity and others provide measures or comments based on the current poster design itself.

For a particular educational context, a teacher could provide a post-game questionnaire or a form to be filled out during the game that would ask the student to report on some of the critic's definitions of creativity or attitudes towards the process of design. The critics are intended to be varied enough to provide evaluations that are somewhat inconsistent with one another, simulating the diverse attitudes of real critics and helping the player to realize and cope with the subjectivity of the process of evaluating creativity.

2.1.2 Winning. In its current form, the game has a very simple notion of winning, which is to create a poster that includes all of the provided items of textual information. This will necessitate subdividing the poster area into at least this many rectangles to allow all the text items to be added. The layout, images, rectangle background colors, text colors and styling don't actually affect the determination of whether a state is a goal (winning) state or not. On the other hand, we can make a distinction between winning and winning well, the latter meaning not only winning, but achieving a favorable critique from a critic that doesn't give a favorable critique to every solution. By making the criterion for winning rather simple and easy, we intend to make players feel happy enough that they might like to play again and strive to please the critics rather than simply reaching an official goal state. Overall scoring has not yet

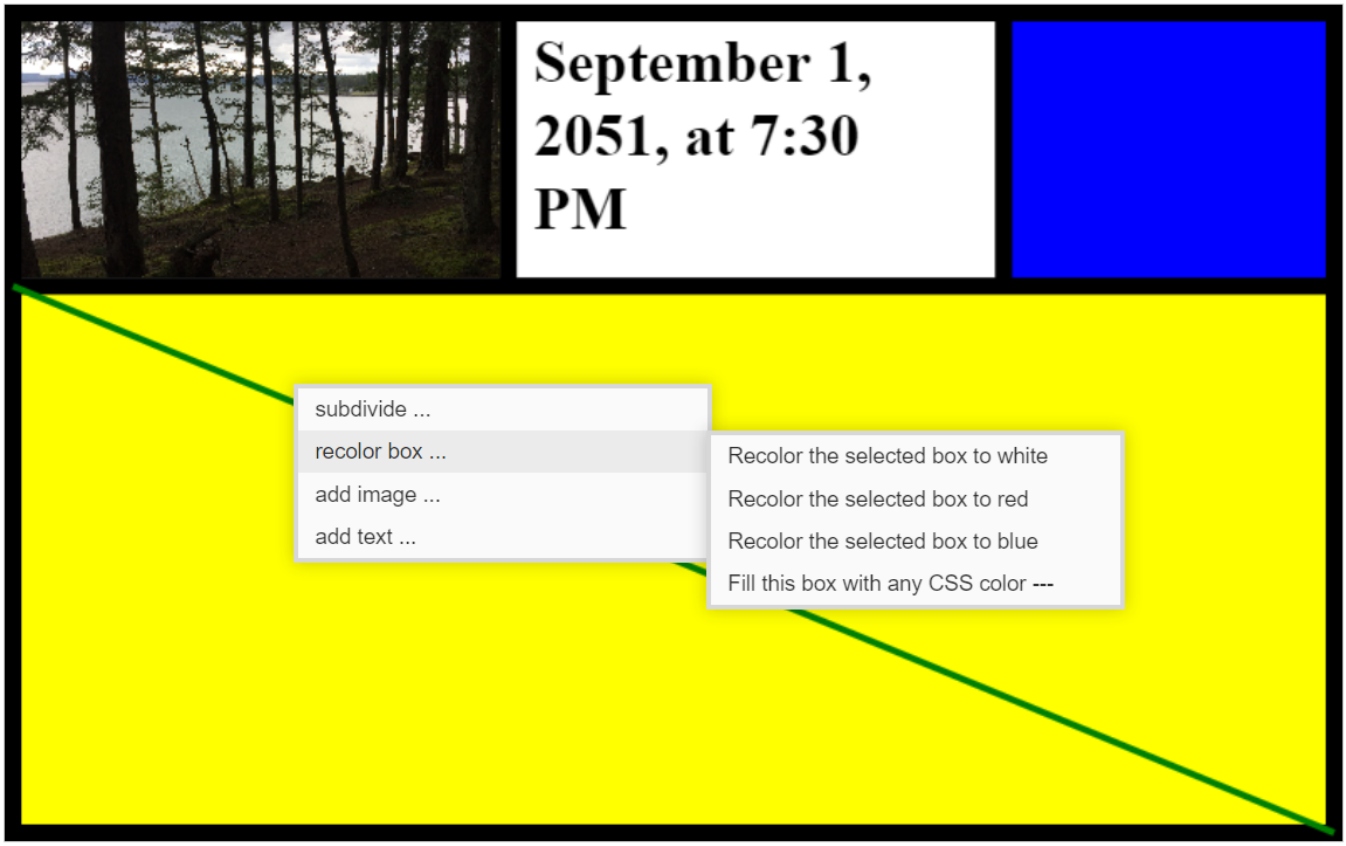

Figure 2: A poster at an early stage of design. A two-level popup menu is shown. The player right-clicked on the yellow rectangle to select that rectangle and activate the menu. Some of the player's options are shown, such as recoloring the rectangle, adding text, adding an image, changing the styling, etc.

been incorporated, but we may make it the main function of a "supercritic" who "consults" the other critics.

2.2 Overall Design

The current prototype of the game is directed at Buchanan's "First Order of Design"[4] concerning signs and symbols, or graphic design/visual design/information design (and neither industrial products, services nor organizational systems).

The game is designed, from a structural point of view, such that the player will be navigating a space of possible partial designs of posters, beginning with a blank space and, ideally, ending with a nice poster that meets a basic criterion of including the required information about the concert. The exploration constitutes a traversal of parts of the problem space of partial designs.

The main menu appears as a popup menu whenever the player right-clicks or control-clicks on the canvas area where the poster is in progress. The menu is hierarchical, with sub-menus that appear when menu items in the main menu are moused over. There are two kinds of menu items: those that immediately change the current design, for example by styling some text or adding an image, and those that require an intermediate step such as choosing a color from a color-picker or a size parameter from a valid range of values.

In its current incarnation, the game presents a fixed set of options for each of two content categories: images and textual information. The images have been pre-chosen to be at least somewhat relevant to the task, but varied enough to offer some room for different selection and different end results. The textual information provided comes in titles, phrases, or short paragraphs of varying lengths and importance to the overall event description. The importance is not necessarily told to the player, so that one aspect of the game is to decide what items of information to make most prominent in the design. A player might find out that prominence of some information matters in feedback from one of the critics.

3 CREATIVITY CONCEPTS IN PLAY

While much of what has been studied about in creativity relates to ways people can become more creative, our game is concerned with issues at a more general, theoretical level: what are the characteristics of a creative solution to a problem, and what sorts of aspects go into evaluating creativity? What influences come from the thoughts and efforts of the creator? How do the tools affect both the process of creating and the mind of the creator? And what role does a community or a sociocultural context play in creativity and its assessment?

The topics discussed below are general issues of importance which might be challenging to investigate in real-world contexts but which can be approached in a game context in ways that might go straight to the core of the matter through the simplification that games can offer. In fact, that very idea of simplification is related to the first topic: constraints.

3.1 Creativity Constraints

Constraints have been found to play a surprising role in many creative contexts: liberating people to find solutions to problems where they would otherwise be stymied by too much freedom[12]. Constraints take various forms in situations where people may be creating. Clearest are natural limitations of what is possible due to physical or economical conditions. People have limited time, limited space and limited materials with which to design and build an outdoor patio, or a child's dollhouse. After constraints due to natural limitations come artificially made constraints. Artificial rules such as the requirement that an architectural design be formulated in terms of a three-by-three grid of squares had an important role in past generations of architectural training and are having a resurgence of interest today[2].

In The Creativity Game, there essentially three kinds of constraints on what the player does: (a) there are constraints resulting from the choice of framework and the overall set of graphic-design tools available at all within the game, (b) there are explicit constraints that hide or enable particular tools according to dynamics of the game, and then (c) there are external constraints having to do with player time available and motivation, internet connectivity, and so forth. As a platform for doing research, the constraints that are most easily controlled by experimenters are in group (b), where simple game mechanic changes can be used to set up alternative conditions for an experiment. Those issues in group (c) could be affected by creating conditions favorable to engagement, such as setting up nice computers with good internet connections and providing refreshments; these conditions could also be measured with questionnaires.

3.2 Novelty, Originality

Following Boden's definition at the beginning of her book[1], The Creativity Game makes explicit reference to novelty, surprise, and value both in its design materials and during play. Actually determining numeric judgments for these is a design issue we discuss in more detail in the technical section.

3.2.1 Novelty. P-novelty (novel with respect to the individual, psychologically) can be assessed in the game when a player engages in multiple sessions. By saving the posters at the end of each session, marked with the ID of the player, it is possible later to make comparisons between a new poster and the player's earlier posters. Novelty then is based on differences between new and old. The differences are computed on multiple aspects of a poster and combined into aggregate evaluations.

H-novelty (novel with respect to the entire history of previous solutions) can be similarly computed but using a different population of old posters – the full collection of posters from a sample group of players or community of players. As a shortcut and proxy for this, the current version of the game includes some static stand-ins for features of past solutions.

3.2.2 Value or Usefulness. Prima-facie determination of value is based on whether the required information has been included in the poster, and whether enough clarity and prominence has been given to the more important elements. We discuss this further in the technical section.

3.2.3 Surprise. Surprise might be considered to be the most subjective attribute to assess, but it is not difficult to come up with narratives that support a critic's expression of surprise upon considering a particular poster design or design trajectory. Such expressions can both teach students to appreciate the prospect of surprise in their design process and to realize that different critics tend to react differently.

3.3 Socio-Cultural Context

> Creativity does not happen inside people's heads but in the interaction between a person's thoughts and a sociocultural context. It is a systemic rather than an individual phenomenon.
>
> — Mihali Czikszentmihalyi[5]

The Creativity Game offers a game mechanic we call critiques, which are on-demand evaluations or comments on the player's work so far. There are several potential aspects to a critique: (a) attribution to a simulated persona, such as a famous artist or philosopher. Thus each critique comes from a virtual character – a critic. These characters are represented only by name and by their critiques. (b) some words of wisdom, such as a quotation, or an explanation of an idea related to creativity or to the design process. Such words may be apropos to the state of the session or not especially. (c) an evaluation. This means that the critique may involve some sort of computation such as a measurement of some part of the design (the current state) or the design process (the history of manipulations within the session) of the player. It can also involve a comparison of the player's work with the past work of that player, other players, or proxy representations for experts or a larger socio-cultural community. Some of the computational aspects of creating critiques are discussed in the technical section.

3.4 Transformation

The notion of transformation comes up in Boden's characterization of advanced creativity. The Creativity Game provides a concrete context for discussing transformation in that the state space can be dynamically changed during play, to some extent. We've already mentioned how constraints, such as the set of available tools, can be dynamically changed for different phases of a session. Such changes can prompt changes in the player's conceptual spaces, too.

Much as commercial games may be designed with "levels" that represent distinct challenges in a sequence of more and more difficult settings, The Creativity Game has something like an Easter Egg that when discovered, enables a vastly broader range of parameters to be used in certain operators such as color selection. This effectively enlarges the level-one state space by an order of magnitude, and allows a much wider choice of colors.

4 TECHNICAL DESCRIPTION

This section explains the technical setup including a brief presentation of the critics.

4.1 Software Structure

The game software comprises several interconnected modules as shown in Figure 7. The central components make up the general game infrastructure: the user interface, application engine, and the general (domain-independent) critics. The user interface includes the workspace (an HTML canvas element), and pop-up menus for selecting and applying operators that transform the current design. There is also a general control panel area in the interface for undoing and redoing operations and for requesting critiques.

The system components on the left side of Fig. 7 are domain-specific and/or problem-specific. In the current implementation the problem is to design a graphical poster using certain textual information and images. The formulation module defines the actual operations that the player can use to transform the current design into a new one, typically by subdividing a region in the poster or adding content in a region. Were the problem domain to be changed to musical composition, the formulation would define a set of operations for adding and modifying notes, phrases, instrumentation, etc., and a goal criterion such as the completion of a song with a particular number of measure bars or song structure.

One of the problem-specific components is the set of critics available that require information about the state details (i.e., the particulars of the current version of the design in progress, as well as how those have changed during the session). These critics may also need the details of particular states in past sessions by the current player or even other players, particularly when the critic is trying to assess novelty at the personal level (e.g., for Boden's P-creativity) or at a community/historical level (e.g., for her H-creativity).

4.2 Critics

The Creativity Game currently offers five critics, each of which can be queried multiple times.

Bodenian: Provides comments on novelty, value, and surprise. Novelty is assessed by measuring differences between the player's design and reference designs that serve as proxies for prior art. Computing one such difference is explained in Fig.3.

Mondrian-ian: Comments here on colors, although rectangular subdivision is facilitated in the game (see Figs. 4,5).

Okeeffian: Emphasizes the floral;

Domain-Independent: Session statistics;

FlowDoctor: Csikszentmihalyi-style flow discussion as in [5].

Critics have access not only to the player's current design, but the session history, including earlier critiques.

5 SUMMARY AND FUTURE WORK

We have presented the design and prototype of "The Creativity Game," a browser-based artistic-design game that can support teaching and learning about the theoretical aspects of creativity. A player is presented with the task of designing a poster to advertise a concert to raise funds for a not-for-profit organization. A player wins by completing a poster with all the required information. However, much of the educational prompts come from simulated critics that comment on what the player has done.

In the future, we plan to test the game with college students and assess the game's effectiveness in supporting the teaching and learning of theoretical aspects of creativity such as those presented at the beginning of Boden's classic work[1]. We thank the reviewers for their comments and suggestions.

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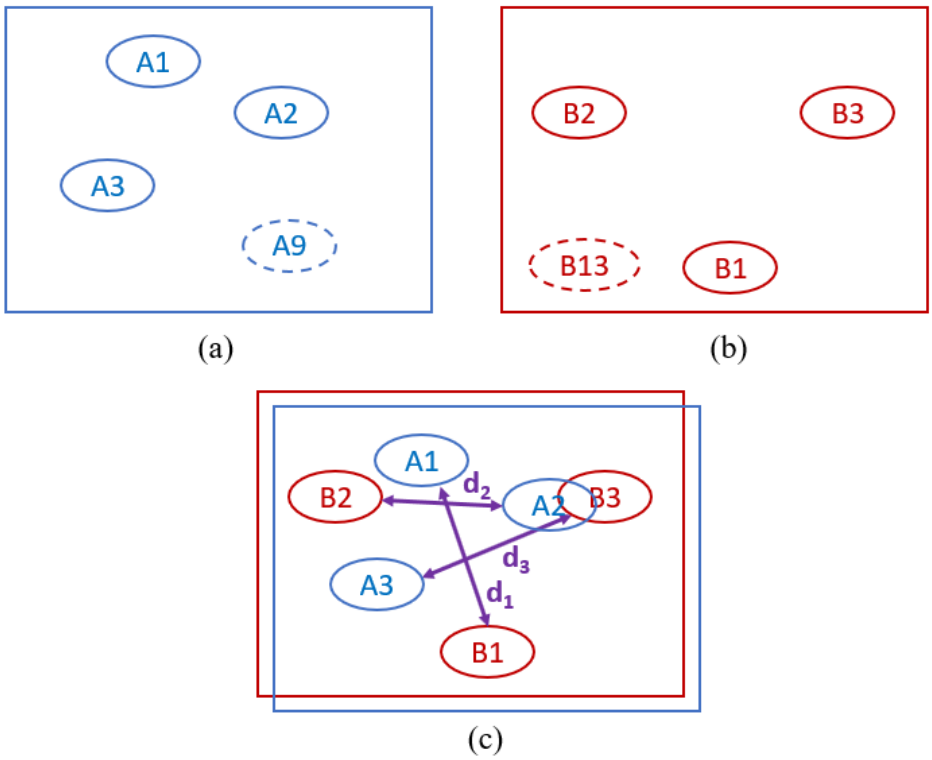

Figure 3: Layout difference: one of many means of comparing designs when assessing novelty. Here (a) and (b) show alternative arrangements of three pieces of information (in corresponding pairs) plus some additional information in each arrangement which doesn't correspond to anything in the other layout. The average of centroid distances is $(d_1 + d_2 + d_3)/3$, where each d_i is a Euclidean distance. Centroids may be computed in multiple ways including centers of bounding boxes, or centers of mass of the text pixels within individual text items.

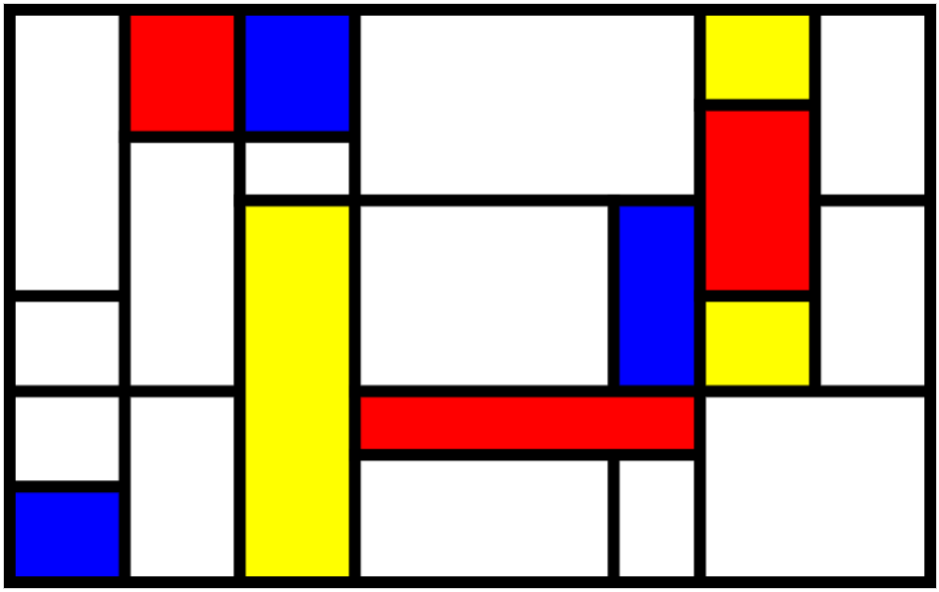

Figure 4: A partial solution in The Creativity Game that might please a Mondrian-oriented critic.

Figure 5: A valid solution to the poster problem that is based on the Mondrian layout.

Figure 6: Another valid solution to the poster problem that still involves the Mondrian layout but has added images. These images provide additional information and richness to the design, but destroy much of the Mondrian aesthetic, which might displease the critic.

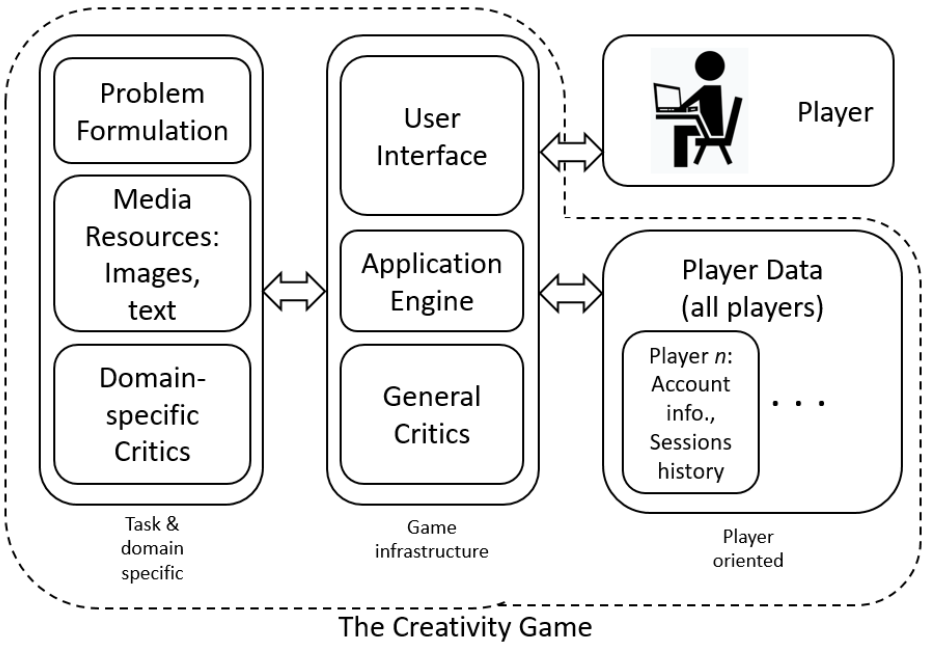

Figure 7: A system diagram for The Creativity Game, showing the logical separation of the three major components: game infrastructure in the middle, task-oriented information and code on the left, and player-oriented information on the right.