CREATIVE STORIES: A STORYTELLING GAME FOSTERING CREATIVITY

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ABSTRACT

The process of identifying techniques for fostering creativity, and applying these theoretical constructs in real-world educational activities, is, by nature, multifaceted and not straightforward, pertaining to several fields such as cognitive theory and psychology. Furthermore, the quantification of the impact of different activities on creativity is a challenging and not yet thoroughly investigated task. In this paper, we present Semantic Lateral Thinking as a candidate for fostering creative thinking within storytelling educational activities. We describe a set of tools implementing Semantic Lateral Thinking techniques over storytelling, and we present Creative Stories, a digital storytelling game incorporating these tools. Furthermore, we propose a metric for quantifying creativity within the game, leading to the evaluation of the creativity exhibited in the stories produced within the game in relation to the usage of the Semantic Lateral Thinking stimuli provided by the relevant tools.

KEYWORDS

Digital Educational Games, Creativity Metrics, Semantic Lateral Thinking.

1. INTRODUCTION

"Human-creativity is something of a mystery, not to say a paradox", states Boden in her book *The Creative Mind* (Boden, 2004), when introducing us as to the 'what' and 'how' of creativity. Apart from unveiling the mystery of human creativity, i.e. the ability to come up with ideas or artefacts that are new, surprising, and valuable, she also discusses how computers can help us understand it.

Along with such philosophical approaches, research results from neuroscience should also be considered in the process of revealing/ understanding the Human Creative Process. Such an example is the work of (Limb and Braun, 2008), who examine how the human mind perceives complex auditory stimuli e.g. music. In this case, they look at the brains of improvising musicians and study what parts of the brain are involved in the kind of deep creativity that happens when a musician is really in the groove. Their research has deep implications for the understanding of creativity of all kinds. (Nachmanovitch, 1990), an improvisational violinist, computer artist and educator, in his book Free play states that creativity arises from bricolage, from working with whatever odd assortment of funny-shaped materials we have at hand, including our odd assortment of funny-shaped selves.

In the process of involving machines in the creative work, (Lubart, 2005) includes the case of Human-Computer cooperation during idea production and proposes a creative thinking strategy, which relies on random or semi-random search mechanisms to generate novel, unconventional ideas. The role of machines in this case is to implement random searches that challenge humans in the process of selecting/ generating new/ innovative ideas and perhaps turning them into creative products. In this context, the Semantic Lateral Thinking theory is particularly well-suited to establish the cooperative framework, by implementing automated components that adhere to the theory and applying them to a suitable educational medium, such as open-ended digital games. In this paper, we discuss on the core characteristics of the Semantic Lateral Thinking theory, describe its application in a digital storytelling educational game and present metrics that help us quantify the impact of the overall process on fostering the creativity of the participating players.

The paper is structured as follows: Section 2 discusses on some of the techniques proposed by the Semantic Lateral Thinking theoretical framework for fostering creativity. Section 3 briefly presents the application of those Semantic Lateral Thinking techniques in storytelling activities via the usage of appropriate computational tools. Section 4 showcases Creative Stories, a storytelling game that incorporates tools for introducing these tools in a gamified environment. Section 5 presents the scoring mechanism incorporated in the Creative Stories game, intended on quantifying the perceived creativity within the game. We conclude and indicate our future steps in Section 6.

2. SEMANTIC LATERAL THINKING (SLT) TECHNIQUES

The term Lateral Thinking was invented by (De Bono, 1970). It adheres to the tendency of self-organizing systems, such as the human brain, to form and move across asymmetric patterns. Tools and processes supporting lateral thinking aim to assist that "lateral" movement, providing the means to escape from a local optimum in a thinking process towards a more global optimum.

Semantic Lateral Thinking (SLT) involves the use of different conceptual Po (De Bono, 1972), (De Bono, 1990), a tool or an operator meant to provoke and dislocate from habitual patterns and forms, as well as disassociate established connections. Several techniques can support SLT e.g. Random Stimulus, and/or Re-conceptualization.

The main principle of the Random Stimulus technique is the introduction of a foreign conceptual element with the purpose of disrupting preconceived notions and habitual patterns of thought. The human actor is thus enforced to integrate/ exploit the foreign element in the production of a solution/ idea, and bring together disparate domains.

Randomness is the main guarantor of foreignness and hence of stimulation of creativity. Foreignness in this context has two main dimensions: (a) It is important that the human actor feels that he/ she has to somehow integrate/ exploit an element which is introduced completely from without, whose introduction is in no way under the his/ her control. In some ways an intruder has to be re-conceptualized as a friendly aid; and (b) the new element should, at least initially, be as unconnected as possible to the subject/ type/ structure of the problem. By doing so, we someway ensure that no unconscious/ unobserved pre-established analogies, preferences and connections creep in the selection of the stimulus. After the presentation of the problem, one is asked to use creatively in the reasoning process the random stimulus provided.

Re-conceptualization involves the use of already established solutions and ideas in new environments. One is encouraged in exploiting the potential of familiarity in the production of novel ideas. The familiar features of the established solution/ idea will re-inscribe themselves on the unfamiliar environment or appear in a new light.

The core distinctive characteristics of the SLT theory –randomness, introduction of external stimuli and re-consideration of an idea in a new environment- constitute digital educational games as a highly relevant platform for implementing and testing the effectiveness of the theory on fostering human creativity. The rest of the paper presents the application of the aforementioned SLT techniques in a storytelling game, via the usage of relevant computational tools, and showcases the proposed foundation for measuring its effectiveness on the attempt to foster creativity.

3. INCORPORATING SEMANTIC LATERAL THINKING IN STORYTELLING ACTIVITIES

In this section, we briefly present a set of computational tools that transparently support Semantic Lateral Thinking techniques. These tools are focused on textual information, that is, the provided elements are words or phrases that act as the random / external stimulus for the humans involved in the activity. The underlying semantics and contexts of these words, are to be analyzed and lead to alternate paths of thought, thus fostering out-of-the-box, creative thinking.

3.1 Thinking Seeds Generator

The Thinking Seeds Generator provides a textual stimulus, having a varying semantic distance from its input. The produced word, as it is semantically distant from the initial state, is meant to act as an initiative to think out-of-the-box, re-contextualize ideas or be led to examine other perspectives of a problem / situation.

The input of the Thinking Seeds Generator is a seed phrase and a difficulty degree, which denotes the semantic distance between the random words that will be returned and the initial phrase. In this context, the semantic distance of two terms is the number of edges in the WordNet [Fellbaum, 1998] synset graph that must be traversed in order to reach to a synset starting from another- specific- synset.

The initial word to be used for the process is determined depending on the size of the textual input. When the input is a single word or a phrase up to three words, the input is processed as it is. In the case of larger texts, the service discovers the dominant terms within the text as follows:

1. Stopwords are removed from the text;
2. The remaining words are stemmed, and hashed with respect to their stem;
3. The three (3) most frequent stems are considered as dominant and the words having these stems are considered the dominant words within the text;
4. One of the dominant words is selected randomly as the seed to be used.

Following the process of determining the seed word, the service traverses the WordNet graph according to the following methodology:

1. Retrieve the WordNet synsets to which the seed word belongs;
2. Start from the synset containing the most words;
3. Select the word in the selected synset that belongs to the most synsets;
4. Repeat the first two steps for the selected word until the number of steps is equal to the set difficulty;
5. Select all the words belonging to the last visited synset.
6. Randomly pick one of the words belonging to this synset.

3.2 Web Miner

The Web Miner is used to provide a summary of web content that is related to an input text segment of variable size. The summary is expressed as a tag cloud structure, i.e. the service returns a set of dominant words found in the examined web content, along with their frequency of appearance.

The input of the service is a word or short phrase, and an indicator that specifies if the service should only handle content safe for children. The service invokes a Search Engine wrapper and retrieves the HTML content of the first 50 results returned by the search engine. The content is cleaned using the boilerpipe library [Boilerpipe, 2014] in order to obtain the textual content of these pages. The stopwords present are removed and the remaining content is stemmed –using the Snowball stemmer [Snowball, 2014] - and hashed in order to calculate the TF-IDF value for each distinct stem.

Let P the number of pages returned from the Search Engine wrapper, p an individual page in P and t a distinct stem. The weighted frequency of t in P is:

$$WF(t,P) = \frac{\sum_{p \in P} tf(t,p) \times idf(t,P)}{|P|}$$

where tf is the logarithmically scaled term frequency of term t in a page p

$$tf(t,p) = \log\left(f(t,p) + 1\right)$$

and idf is the inverse document frequency of this term in set P

$$idf(t,P) = \log \frac{|P|}{|\{p \in P : t \in p\}|}$$

For each distinct stem, the most frequent form (with respect to its raw number of occurrences) is chosen to build a structure that encapsulates the {stem form, weighted frequency} pairs for the entire content.

3.3 Cloud of Thoughts

The Cloud of Thoughts service provides a summary of a text segment, by examining the dominant words / short phrases found within the segment and returning them as a tag cloud structure. Its aim is to identify and present the major ideas present in the text, giving to the user a synopsis of others' thoughts that can lead him / her to change thinking perspectives, guiding his thought in a different path.

The service is invoked with the text to be summarized as its input. After the removal of stopwords, it calculates the logarithmically scaled term frequency as shown above. Finally, a structure that encapsulates the {dominant stem form, term frequency} pairs is returned.

3.4 Competitive Thinking Spaces

The Competitive Thinking Spaces service relies on the premise that a text segment may contain different aspects / points of view and the user can focus on a specific one to proceed with a line of thought. Thus, the service analyses a text fragment and identifies different groupings of the concepts included in the fragment, returning them to the caller.

In order to determine the thinking spaces, the service operates on a text segment provided as input. It discards stopwords and then clusters the obtained word set. If the produced clusters exceed a specified number (e.g. 4), the service reduces the clusters to this number, using the distances between the clusters. It finally returns to the calling agent a structure that encapsulates the clusters and the words / phrases belonging to each cluster.

4. THE CREATIVE STORIES GAME

This section provides an example on the usage of the described computational tools in the context of Creative Stories, a storytelling game that uses the various tools in a gamified environment. We firstly present the setup phase for a Creative Stories game session. We proceed to demonstrate the execution of a Creative Stories game session and present the usage of the computational tools within the game.

4.1 Creative Stories Session Setup

The teacher defines the groups that will participate in the Creative Stories game session. He/ She defines the number of groups that will participate in the game session.

The next step is to define the parameters of the actual game that will be used for the game session. The teacher defines the story's theme, the range of difficulty for the input from the computational tools, and the way that the difficulty will progress during the game. Finally, the teacher can select the type of input from computational tools that will be used within the game. The Creative Input option will activate the Thinking Seed Generator and the Web Miner, while the Competitive Thinking Spaces option will activate the eponymous computational tool.

After the teacher has setup the described parameters, the game session can be activated and the students can enroll as members of their group and play the game.

4.2 Creative Stories Game Play

After enrolling in the game session, the players are presented with a multi-panel environment from which they can provide their input, observe the activity of the other groups and get feedback from the computational tools and the teacher. The central panel presents the story fragments created so far by the group (Group 2 in the example) and contains the input field for writing and submitting a new story fragment, along with an indication for the points that will be added for the specific fragment, as they are calculated by the relevant computational tool (analyzed in section 5 of the paper). In the right-side panel, the players can see the progress of the other teams participating in the game session, along with tag clouds that summarize the stories of the other groups and can be used as inspiration and guidance for progressing with the story. These tag clouds are created via the usage of the Cloud of Thoughts tool, called with each group's story as input.

In the left-side panel, the players can observe their current score and use the input from the computational tools for obtaining input to be used within their story. There are two distinct modes of playing the game with respect to the type of automated input that is used, the Creative Input and Competitive Thinking Spaces modes. The next subsections briefly describe the characteristics of each mode.

4.2.1 Creative Input

Figure 1 depicts a mock-up of the game screen in the case that the Creative Input option was selected by the teacher.

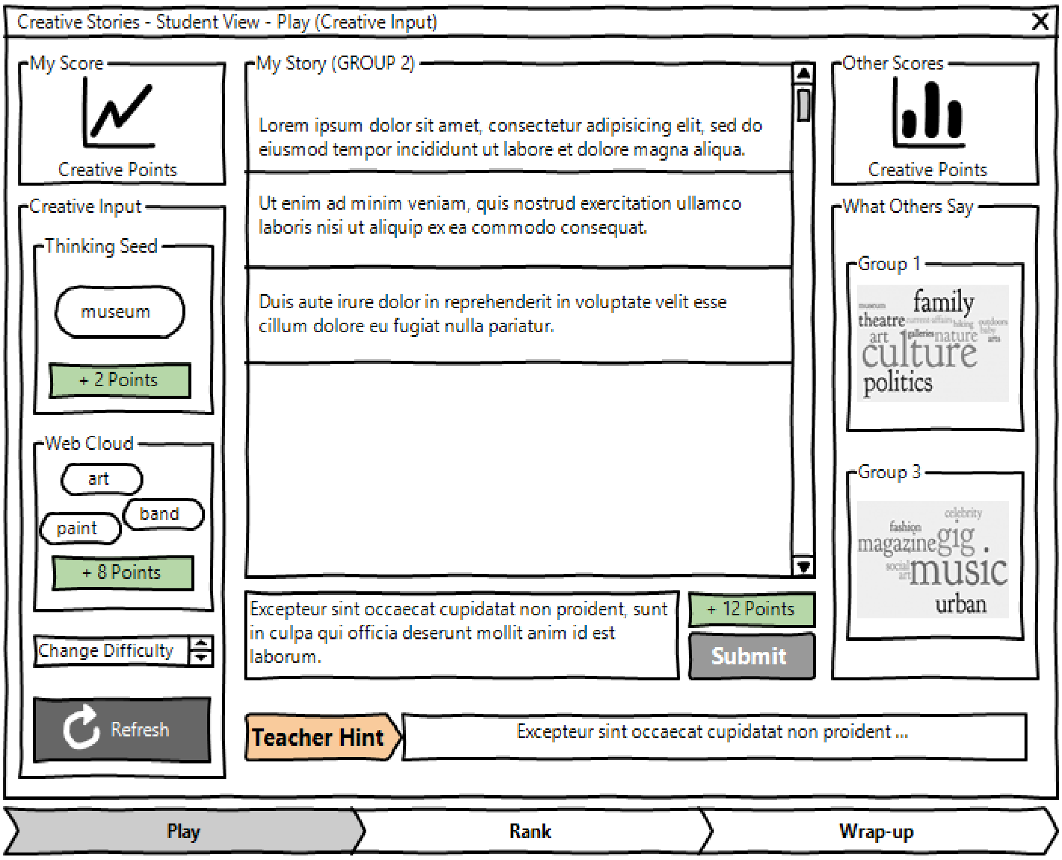

Figure 1. Playing Creative Stories in the Creative Input mode

In this mode, the tools used for providing input to the players are (a) the Thinking Seeds Generator and (b) the Web Miner. In (a) the players are called to use the word or phrase provided by the Thinking Seeds Generator in their story fragment. In (b), the players are called to use all the words included in the tag cloud produced by the Web Miner in the story fragment. Each group is free to modify the difficulty (semantic distance) of the provided input and retrieve a different set of thinking seeds and tag clouds by hitting the refresh button.

4.2.2 Competitive Thinking Spaces

Figure 2 showcases the game screen in the case that the Competitive Thinking Spaces mode is active. In this case, the game uses the Competitive Thinking Spaces tool to provide additional input to the players. The input for the tool is the accumulation of the story fragments produced so far by all the participating groups. The groups try to use every word within one thinking space in order to "conquer" the respective space. When this is accomplished, the particular space becomes unavailable for the remaining groups, which have to focus on a different space.

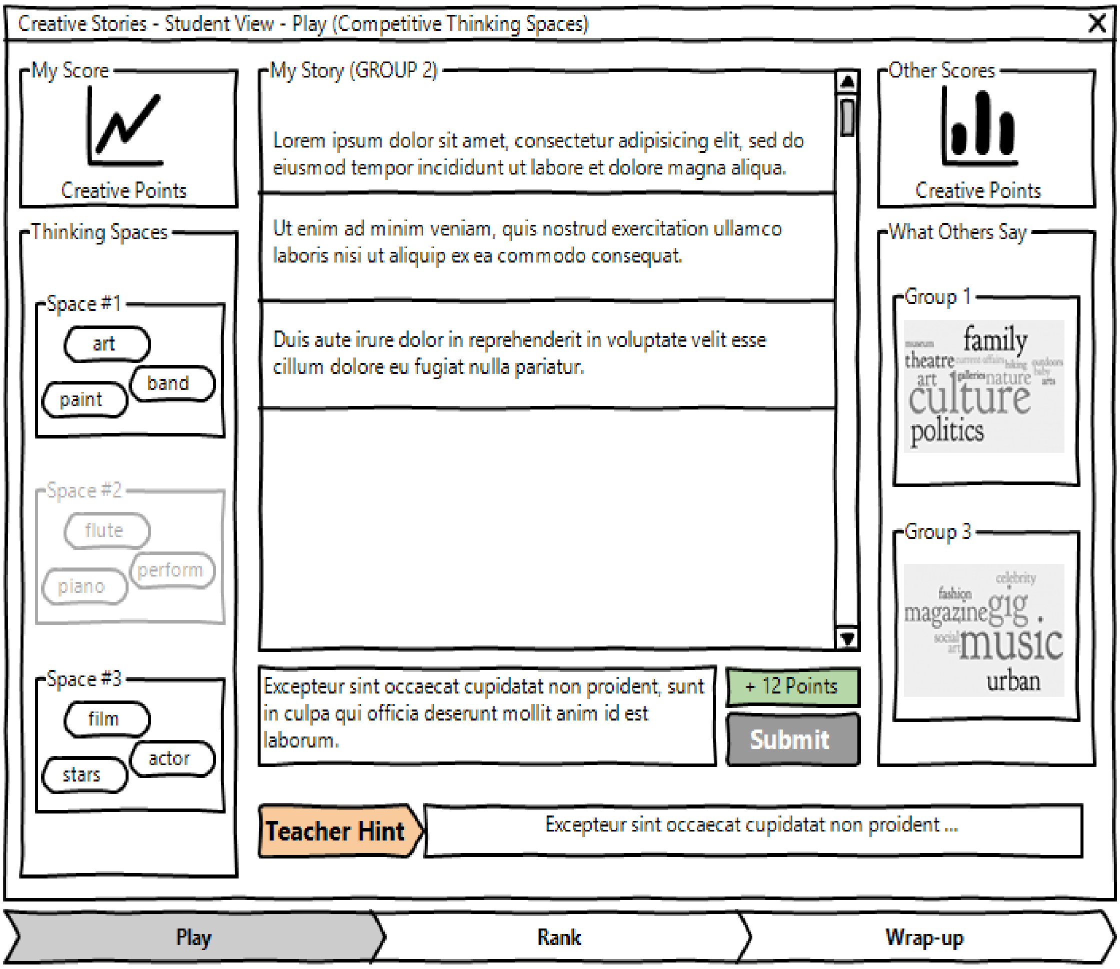

Figure 2. Playing Creative Stories with Competitive Thinking Spaces

5. CREATIVITY METRICS WITHIN CREATIVE STORIES

Creative Stories incorporates a formulization of traditional Computational Creativity metrics, namely Novelty (Lehman and Stanley, 2008), Surprise (Maher, 2013), and Impressiveness (Lehman and Stanley, 2012), in order to apply them over the textual artefacts obtained via the game. More specifically, Novelty is defined as the average semantic distance between the dominant terms included in the textual representation of the story, compared to the average semantic distance of the dominant terms in all stories. Surprise has a strong temporal dimension, which leads to the examination of the story's method of continuation between its distinct fragments. To this end, we conceptualize surprise as the average semantic distances between the consecutive fragments of each story. Impressiveness has two main constituents, Rarity and Recreational effort. To model rarity, we compute the clusters of terms in each story. Following the same approach applied to the computation of the novelty metric, we calculate the semantic distance between the individual clusters. In order to provide an estimation of the rarity for the examined story, we calculate the sum of weights on the min-weight closure of the cluster graph compared to the maximum sum of weights in the story set of the group. On the other hand, Recreational Effort is calculated as the number of different clusters that each story contains, compared to the maximum number of clusters found in a story of the group.

During a Creative Stories session, the participating groups are rewarded with Creative Points, determined by their usage of input from the computational tools, as well as, usage of information from the activities of the other players. The Creative Points are defined as the product of the base Creativity Points returned by the Creativity Points Computation service and a modifier that depends on the usage of the aforementioned elements.

We use two distinct functions for calculating the Creative Points in Creative Stories, depending on the type of input selected for the specific Creative Stories session.

In the case that the Creative Input option is selected, the Creative Points are given by the following equation:

$$CreativePoints(T) = \left(1 + \prod_{i=1}^{N_T}\left(1 + \frac{difficulty_i}{10}\right) + n + \prod_{i=1}^{N_W}\left(1 + \frac{n * difficulty_i}{10}\right) - 2N_O\right) BasePoints(T)$$

In the equation, N_T is the number of times the player used the Thinking Seeds Generator services, N_W is the number of times the player used the Web Miner services, while N_O denotes the number of words that the player used and appear on the tag cloud created from the other players' stories. n is the number of words included in the tag cloud returned by the Web Miner.

In case the Competitive Thinking Spaces is used as the computational tool input for the game session the equation for the calculation of the assigned Creative Points is the following:

$$CreativePoints(T) = N_{Clusters} BasePoints(T) - \frac{1}{2} N_o$$

where, $N_{Clusters}$ is the number of clusters completed by the specific team, and N_o is the number of words that the team used from the tag clouds summarizing the stories of the other teams.

It is expected that the inspection of the values on the traditional creativity metrics and their comparison with the creative points score associated with each story will reveal correlations between the perceived creativity exhibited within the stories and the usage of SLT stimuli by the players. In this way, we can reveal the impact of the SLT techniques on the creativity of the Creative Stories players and the degree to which the introduced stimuli urged them to be more creative.

6. CONCLUSION

In this paper, we presented Semantic Lateral Thinking (SLT) techniques suitable for fostering creativity, which can be used in storytelling educational activities. We defined a set of computational tools facilitating the implementation of the aforementioned techniques in a digital storytelling game. Finally, we demonstrated the mechanics of such a game, Creative Stories, which builds upon the usage of a Creative Scoring mechanism for quantifying the impact of the SLT stimuli within a story.

Our future work will focus on examining the correlation between the usage of these stimuli and the creativity as perceived by using traditional creativity metrics. Towards this objective, Creative Stories will be used in real-world educational settings, and the obtained results will be analyzed in order to assess the effectiveness of SLT on fostering creativity via its usage within digital educational games.

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