Towards Modelling the User Creative Process in a Sandbox Game

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ABSTRACT

Wallas suggested a four stages model of creative process: a) preparation, b) incubation, c) illumination, d) verification, that has been widely used through the years in several disciplines. In this work we are aiming at defining pattern detection algorithms for modelling the creative process of a user based on the user's activity in MineTest. A qualitative user study allowed us to define and refine patterns related to the creative process of the user while executing a creative task in the game. In addition, through the data collected, important issues have been exposed that will inform future work in the same direction.

KEYWORDS

Creativity; Creative Process; MineTest

1 INTRODUCTION

The process of creativity has been a subject of research in the area of psychology for a long time [1]. The creative process is broadly defined as the sequence of thoughts and actions that leads to novel, adaptive production [2]. Guilford [2] in his defining manuscript argues that there is a general agreement of a four stages model of creativity in accordance also to Wallas [3]: a) preparation, b) incubation, c) illumination, d) verification. On the other hand, there are studies (e.g. [4]) that show that these distinct phases of creative process do not really exist in isolation of one to the other, but rather overlap or even in some cases a person might skip one of these phases during an exercise (e.g. poetry, drawing) [5].

Wallas' four stages model of creativity received a lot of criticism from psychology researchers e.g. [4] both in terms of the four distinct phases and in terms of the generalization of the model, however, this is still one of the most dominant models followed in defining the creative process [6, 7] and the one we follow in this work.

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According to Wallas' [3] creativity process follows four stages in an iterative process:

Stage 1: Knowledge items relevant to the problem are formed. Associations start to arise between them and they are manipulated in small, overlapping groups representing different views but are not yet organized.
Stage 2: Attention is moved away from the problem's network. This phase models the relaxation of constraints and thus, new associations are intuitively formed. At this stage the network is not stable and contradicting knowledge items tend to compensate each other
Stage 3: A potentially stable network of knowledge items starts to form that grows rapidly after a moment of sudden illumination.
Stage 4: Follows a moment of sudden illumination and the user starts to focus again on the problem reflect on the current stable network and breakthrough happens when the user finds a way to connect previous and current ideas together.

Recent studies in the crossroads of Human Computer Interaction, Interaction Design and Human Cognition research are trying to understand the process of creativity in different applications, e.g. computational thinking [8], learning process [9], problem solving ability [10] and gaming [11], either by analyzing behavioral patterns, designing for supporting creativity or by defining models and indicators of creativity.

Open world sandbox games like MineCraft, are designed to encourage the player to go outside of the structured linear gameplay, be creative and interact freely with the virtual world. [11]. Consequently, they are thought to enhance player's problem-solving skills [12]. These open world games, that allow the player to express themselves and, in a way, direct the outcome of the game can be good indicators of one's creative abilities [13, 14] in visual environments. MineCraft, similarly to assembling a Lego structure [15], serves as a case study in examining and understanding the creative process and related behaviors [14].

MineTest[1] (Figure 1) is an open source voxel game using Lua API. There are many versions of the game to choose from where you could survive in a harsh environment, build creatively, or fight other players. MineTest logs game playing information and

[1] https://www.minetest.net/

user activities (digs, places, takes, leaves, joins, activates, crafts, tools, player's activity coordinates, among others) in an activity log (log file in Figure 2), thus we can log user actions.

The work described in this paper is an initial attempt to define a pattern detection model of the individual creative process during game playing in an open source popular game, MineTest.

Figure 1 Scene captured in MineTest from user activity

2 MODELLING THE CREATIVE PROCESS IN MINETEST BASED ON WALLAS' FOUR STAGES MODEL

Following Wallas' four stages of creative process described above, we defined four Stages of creative process based on MineTest game-playing activities:

Stage 1: Capturing user dispersed activity at different locations or isolated behavior – at this stage the user is probably trying to define the scope, identify the problem – problematic areas

Stage 2: Moving away from problematic, not well-defined areas into a different space and starts to reconsider and relaxing constraints showing activity in an area away from the previously problematic areas.

Stage 3: Remains in an area longer, where the user starts to build/shows activity that becomes stable and grows

Stage 4: Reflect to previous activity from Stage 1 and/or Stage 2 and connect to earlier constructions

In order to refine this initial definition of the above four stages of the creative process in MineTest, we ran a user study focusing on qualitative data collection that informed the definition of the pattern detection algorithms.

2.1 Refining Creative Process Stages Definition through User Feedback

The purpose of the user study was twofold: a) improve the initial definition of the creative process stages defined through user feedback and b) validate the patterns.

In this paper we are focusing on the first objective, that is *to improve and refine the definition of the creative process stages* defined in the previous section.

Participants and Procedure

We employed 28 participants (16 males and 12 females) in this study, aged between 22 to 24. We provided users with an instruction manual on how to install MineTest, the basic operations that can be performed and the controls that can be used through the game. The participants had no previous experience with MineTest or MineCraft games. Each participant had to complete five hours of game-play within two weeks, and record their activity using on screen video recording in addition to the log file that was automatically generated by the MineTest platform. Within these five hours the participants needed to build something (e.g. house, castle) of their choice. Then, the videos recorded, and the log files were sent to the researchers for analysis.

Focus Group Session

After the completion of the task, participants were called on a focus group session to discuss their experience. The focus group designed and ran by two of the authors and had a purpose of refining the pattern definition algorithms that would computationally define the four stages of the creative process. This session lasted for two hours and attended by 20 out of the 28 participants.

Thus, three questions were brought up during this session:

FQ1. In general, how did you approach the game play?

a. What did you do initially?

b. Have you had any problems with finding what to build?

c. Have you initially worked on different structures and or areas until you finally worked on what you submitted?

d. Approximately how long did it take you within the five hours to start working on your final creation?

FQ2. Approximately how long did it take you to build your final artifact?

FQ 3. Have you used all the five hours available productively?

The focus group was performed in an informal setting, so the participants felt comfortable in answering the questions in the form of a discussion. In addition to the above questions, participants brought-up other issues related to their activity that were taken into account by the researchers.

2.2 Results

Through the analysis of the data collected from the focus group session we were aiming at refining the creative process stages and define the algorithms for detecting these through the log file.

Regarding FQ1, participants mentioned that it took them some time to orient themselves in the game and understand the operations as well as where and how to start building.

"I started digging initially without any purpose really" – Participant1

"I was trying to understand how to play this game and where should I start from." - Participant2

Through this time users where just 'digging' in the game without having a clear idea in mind on what they wanted to build yet. In addition, a considerable number of users where changing worlds within the game, and others mentioned they were flying above just to explore what is around. It was interesting that students mentioned spending the first hour in getting familiar with the game/environment etc.

In FQ2 answers varied. Students worked on their artefacts mostly for one to two hours until completion (not necessarily continuously). This is important since in a 5-hour long gameplaying activity the logged activity can be divided in different sections of interest for detecting the different stages of the creativity process.

"The hours I believe I worked on something meaningful were between the 2nd to 4th hour of gameplaying" Participant 4

"I don't exactly remember but definitely spent an hour to think of what I would build and how to build it through the game. I spent around 2 hours to finalise my construction". Participant 6

"I think that before I started working I spent some time preparing my inventory, what tools I would need initially etc". – Participant 3

Lastly, FQ3 revealed an expected issue that would be useful for future work and specifically when we utilize the log files for validating the algorithms developed. For the participants, five hours of gameplaying in MineTest was a long time. Participants reported that they did not needed so much time to complete their tasks.

"Approximately the last hour spent for fine tuning what I built before. I just wanted the time to pass since the task had required me to play for 5 hours" – Participant 18

"I built what I wanted within two hours. The rest of the time I was exploring around the world." – Participant 10

The results were taken into account in defining an initial version of pattern detection algorithms that allow us to computationally detect the four stages of the creative process through MineTest. For this, we consider the log files of users' activities as an input thus, we need to formalize the input before defining algorithms that will detect activity patterns in users' game-playing.

2.3 Formalization of the Input

Formalization of the input data is the first step towards the implementation of the pattern recognition algorithms of the four stages of creative process, because it describes the input we are dealing with. The input is aligned with what can be logged from MineTest game.

Firstly, the user U joins the game at a specific Date and Time and similarly leaves the game. The user then selects from a set of Actions: {activates, places, digs, takes, crafts}. Each action is taking place at a specific 3D Coordinate (x,y,z) in the virtual environment of MineTest. Figure 2 provides a sample of the information collected in, and the structure of the user log file.

```
2017-10-03 20:20:51: ACTION[Server]:
User1 joins game.
2017-10-03 20:20:51: ACTION[Server]:
User1 joins game. List of players: User1
2017-10-03 20:21:06: ACTION[Server]:
User1 activates wool:red
2017-10-03 20:21:17: ACTION[Server]:
User1 places node wool:red at (-463,12,-26)
2017-10-03 20:21:18: ACTION[Server]:
User1 digs wool:red at (-463,12,-26)
2017-10-03 20:21:25: ACTION[Server]:
User1 places node wool:red at (-464,13,-28)
2017-10-03 20:21:49: ACTION[Server]:
User1 places node wool:red at (-467,15,-33)
2017-10-03 20:27:17: ACTION[Server]:
User1 takes default:fence_acacia_wood from creative inventory
2017-10-03 20:27:27: ACTION[Server]:
User1 places node default:fence_acacia_wood at (-470,12,-35)
2017-10-03 20:27:35: ACTION[Server]:
User1 digs default:fence_acacia_wood at (-470,12,-35)
2017-10-03 20:28:02: ACTION[Server]:
User1 takes doors:door_steel from creative inventory
```

Figure 2 example of the data collected from the user's activity log file

The Actions performed by a user contribute to the activity of the game and are considered important for the pattern definition and detection algorithms. Based on the set of Actions, the Coordinate (x,y,z) along with Date and Time that the action is taking place, a different pattern can be defined and detected. The user U, activates a tool or material that he/she wants to use, and he/she takes a material or tool from his/her inventory (Figure 3). The user digs through a material and places a material in the world. A user crafts new items in the game by combining a set of materials available

At the moment we are only taking into account the actions and not the materials or tools used by the user. However, these are logged in the user file and will be later considered for improving the algorithms.

Below we will provide the in pseudocode of the algorithms defined for detecting each Stage of the creative process as discussed in the previous section.

Figure 3 Inventory of available tools and material. The user can choose what he/she needs during the game

3 DEFINITIONS OF 4 STAGES OF CREATIVE PROCESS THROUGH MINETEST

The initial and brief definitions of the four stages of the creative process have been presented in Section 2. Taking into consideration the feedback we received from the focus group participants, we refined the initial definition of all stages as below:

Stage 1: Capturing user **dispersed activity** at different locations or **isolated behavior** – at this stage the user is trying to define the scope, identify the problem – engaged in **problematic areas**, trying to **understand the environment**.

Figure 4 provides the pseudocode of the pattern detection algorithm defining Stage 1. At this stage initially, we are looking for activity that was performed in different locations in the game. This is to identify whether the user was involved in any problematic situations. Thus, we need to calculate the distance between two locations in the game. Manhattan Similarity measure employed in our algorithms. After experimentation with different similarity measures (e.g. Manhattan, Cosine, Euclidean) Manhattan provided the most representative results for our purpose.

Based on the participants' comments, during the initial stages of their activity they were mostly 'digging' without purpose. So, we need to capture if |digs| activity is considerably more than |places|. The algorithms here is counting the times that the user digs and places elements in the game.

Next, the participants mentioned that they were looking for a world that they would like (see Figure 5) and they were logging on and off the game. In order to detect these cases the algorithm is detecting whether the user joins the game in consecutive times.

```
        Manhattan Similarity (Coordinate i, Coordinate j)
        If (|digs| at least 4* |places|) then
                Activity=true
        If (Similarity>35) then
        moved from problematic area //threshold
                Distance=true
        If ((|duration|<=20 AND Activity
        =true AND Distance=true) OR (joins>1))
                First stage detected
        Else
                Not detected
Send the index to the next stage function
```

Figure 4 Pseudocode of the algorithm for detecting Stage 1 of the creative process in MineTest

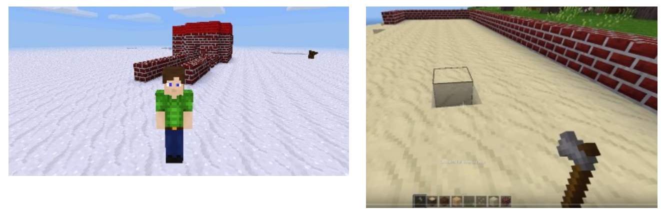

Figure 5 Different worlds in MineTest. A snowy world (left) a desert world (right)

Stage 2: The user is **showing activity in an area away from the previously identified problematic situations**. At this point the user has understood the environment and is starting to show some **consistent activity**. The user is **activating and preparing his/her inventory**.

Moving to Stage 2 of the creative process, the algorithm at this stage continues based on the detection of activity away from the previously detected areas (Stage 1). Participants indicated that at this point they were looking at developing their inventory and needed to decide on the material that they would use the most. They then placed those materials in their inventory for immediate use.

Furthermore, some of the participants mentioned that at this point they crafted some tools and items that they would use in their construction.

Based on the participants' comments at this stage we are looking for consistency in the activity of the user so, we are looking for specific actions. takes indicates that the user takes a tool from the inventory provided. activates refers to the activation of specific material in the inventory of the user and crafts indicates that the user developed an item using raw material provided in the MineTest inventory.

If the above actions are detected according to the algorithm in Figure 6, then Stage 2 is detected.

```
Manhattan Similarity (Coordinate i, Coordinate j) //detected in the previous stage

If |takes| >1 then takesVar=true
        For Time <= 60 minutes
        count minutes
        duration = minutes
        If (duration<=60 AND takesVar=true AND
        |activates| >2 AND |crafts| >1)
                Second stage detected
        Else
                Not detected
        Send the index to the next stage function
```

Figure 6 Pseudocode of the algorithm for detecting Stage 2 of the creative process in MineTest

Stage 3: The user **remains in an area for a longer period**, where the user starts to **build/shows activity** that becomes **stable and grows**.

At this stage we are looking for a persistent and long activity around a specific area where the user performed creative actions. Thus, the similarity between the Coordinates of the locations the user shows activity at is detected along with the Time (duration) the activity continued. According to user feedback during their active construction phase (Stage 3) users were placing items more than digging items from the environment. Thus, at this Stage we are interested about the number of |digs| actions to be less than the |places| actions of the user. In Figure 7 the algorithm for detecting the above patterns of action is presented.

```
//keep the coordinates of the first record
        Count |digs|
        Count |places|
        Similarity (coordinate i, coordinate j)
        If (Similarity<35) then //threshold, the user is working on the same area
                Distance=true
        If (|places| at least 4* |digs|) then
                Activity=true
        If ((duration<=60 AND Activity=true AND Distance=true))
                Third stage detected
        Else
                Not detected
        *Send the index to the next stage function
```

Figure 7 Pseudocode of the algorithm for detecting Stage 3 of the creative process in MineTest

Stage 4: Reflect to **previous activity** from Stage 1 and/or Stage 2 and **connect to earlier constructions**.

Based on Walla's creativity model at Stage 4 we are looking for connections between the latest activity of the user and previously abandoned tries. So, taking into account the focus group results, where users mentioned going back to earlier structures and trying to connect with their current actions, the patterns defined for detecting Stage 4 (Figure 8) in MineTest focuses on the similarity between Coordinates the user previously worked and abandoned and recently visited areas where he showed activity in Stage 3.

```
//Check the existing coordinate with Stage 1 (Similarity) to see if the player came back to the problematic area
//came_back Boolean variable will indicate if the user returned to previously explored areas
If (Similarity<35) then came_back =true
        If (came_back==true) then Stage 4 detected

//For the rest of the log file check if the user places items continuously and check the similarity between the existing coordinate and the first coordinate
If (Similarity<35) then
        came_back=true
        If (came_back==true) then
                Stage 4 detected
        else
                not detected
```

Figure 8 Pseudocode of the algorithm for detecting Stage 4 of the creative process in MineTest

4 CONCLUSIONS & FUTURE WORK

Following research in psychology indicating that creativity can be learnt and can be coached [5], this work can be an initial step towards coaching creativity within an open virtual world. The long-term goal of the work presented in this paper is to capture patterns of user creative process during gameplaying and following the architecture of adaptive systems [16] to support users by creating awareness of their creain terms of creativity and help them become more creative.

The above algorithms are being implemented for extracting the four stages of creative process as defined by Wallas. The 28 user log files collected during the study presented in Section 2.1 will be used to validate the above algorithms. It is expected that we will be able to detect the patterns defined above. However, we are not expecting to detect all four stages in all files. Research in creativity suggests that not all people are following distinct stages during their creative process [1] with some skipping one stage or taking longer time in another.

A second focus group is planned, inviting selected users who will be presented with detected patterns along with the respective 'scenes' from the video recorded files captured during the study (Section 2.1). They will be called to comment on the results for further validation and improvement of the algorithms.

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