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Assessing Games, Game Features & Meta-Communities on their contribution to Creativity & Valued Outcomes

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Abstract

Games are controversial. Do they stimulate creative thinking or harm creativity? And if they do stimulate creativity, what is the value of the creative outcomes? If one wants to design a game to stimulate creativity, what features of a game stimulate creativity? In this Internet connected world where gaming communities proliferate, do gaming communities contribute to creativity? This review of the literature provides insights into these and related questions. Under certain conditions the literature indicates that either playing or adapting games may be useful in stimulating creativity. Beyond the game, supplementing games with interfaces and other tools in order to gather feedback is possibly useful for assessing creativity. Gaps in understanding games and gaming community synergy or anergy with creativity offer extensive opportunities for future research. One gap is understanding the level of creativity and the value of creative outcomes among members of technology-related gaming meta-communities. If technology games and related meta-communities stimulate, strengthen, and possibly sustain memory, problem solving, critical thinking, and creativity in the individual, does the resultant creativity in the individual transfer over time to valued outcomes in related technology or engineering fields?

Keywords*: Engineering Education, Creativity, Games, Communities, Critical thinking*

1. Introduction

"Inventive genius" and "creative thinkers and leaders" are critical to success in competitive endeavors and the change in and modernization of societies [1-3]. The notion of creativity is long standing with the Torrance Tests of Creative Thinking (TTCT) [4] and its revisions and variants being widely known and accepted measures of creativity [5]. More recently, declines in competitiveness [6], international competitiveness (Florida, 2005), and perceived drops in creativity [7] motivate creativity research.

Gaps in advancing creativity exist between various communities [8, 9]. Communities may be user groups of particular software [10, 11], organizations, cultures [12, 13] or combinations thereof. Factors within science and technology influence the value of creative outcomes from communities (Raka, 2001). Further, within community factors such as differences in levels of communication, collaboration, risk-taking, support, and ability to re-purpose tools contribute to differences in levels of creative activity and the value of creative outcomes [14-16]. Tensions within a community also impact creative outcomes whether those tensions be of the nature of "creativity rivalry" [17] and/or "voluntary cooperation to facilitate free exchange of ideas and to stimulate creativity" [18]. Understanding the relationship of these dynamic factors on creativity and valued outcomes remains an area of important research.

2. Games and Creativity

The ability of games to contribute to creativity is controversial. Rubin [19] argues, that while it is possible that games may be beneficial to creativity, if reading skill were to atrophy then gaming would have a detrimental effect on creativity. Kim [20] argues technology addiction may be at the root of a creativity crisis in the United States. Contrasting with negative assessments, Kow and Nardi [21] argue gaming may be a source of creativity and that creativity may evolve through gaming communities such as official game forums or wikis. In a mixed assessment, Yeh, et al. [22] found that game induced stress influences creativity by either concentrating cortisol thus improving working memory OR decreasing creativity via anger and frustration.

Connolly, et al. [23] reviewed the empirical results of 129 studies of the use of games in education. These studies covered not only creativity but a diverse range of by-products – learning, cognitive, motor skill, behavioral, affective, motivational, etc. Most studies reported some positive influence of the use of a game, including in the realm of creativity, but levels varied greatly by discipline and level of rigor. Lacking in the Connolly et al assessment is a focus on features of games and aspects of gaming communities that may stimulate creativity. Selection of game features in design may be important to stimulating creativity as Cook, et al. [10] suggest a number of themes that game designers should address for fostering creativity. Gaming community synergies or anergy may be important to stimulating creativity as Füller, et al. [24] found that positive co-creation positively correlated with quantity and quality of competitive designs and sense of community moderated over co-creation experience and final creative output. Additionally, Gebauer, et al. [25] found, in the presence of conflict during a co-creation contest, perceived fairness within the community mediated over satisfaction with the creative outcome and the sense of community. Table 1 below consolidates and reviews recent findings on traditional games in terms of creativity activity, by-products of the game, assessment of creativity in game by-products, game features that promote creativity, and observations with respect to community synergy or anergy.

Authors	Game Activity	Game facilitated Creative Activity & By-products	Assessment team & Analytical Approach to Assessing Creativity in Gaming By-products:	Game Features that promote Creativity were:	Observations with respect to Game-centric Synergy or Anergy within a Community
Peppler and Solomou [11]	Adapt & Play Pre-existing Multi-User Virtual Environment	Students Freely Create Buildings	Researchers assessed patterns in player creative behavior by monitoring chat logs, interviews and player peer assessments of creations outcomes .	Integration of Chat logs in the building zone of the world enabled immersion in the creative narrative.	"The mechanism that enables creative ideas to spread and mature is the act of conversation."
Boyce, et al. [26]	Adapt & Play Pre-existing Game	Player-designed puzzles	BeadLoom Game experts rated the creativity of the student products.	Custom Puzzle game mode with embedded ability to publish puzzles, leaderboards, and a rating and commenting system.	If no formal means of sharing art, designs failed to evolve in the community much beyond mimicry
Sisarica, et al. [27]	Adapt & Play Pre-existing Game	Role-Play in a detective story	Expert peer review determined the usefulness and novelty of ideas generated.	Explicit adaptation within the game of Brainstorming, Random Combinations, Excursion and Other Worlds.	Game world needs to be semantically close to the training domain to facilitate transfer
Yang [28]	Adapt & Play Pre-existing Games	Game play and integrated HOTS tasks	Researchers administered the TTCT with Pictures to measure creative thinking skills.	Simulation reinforced by creative thinking exercises.	Game play must be supplemented by priming and additional guidance.
Dickey [29]	Play a pre-existing game outside of class.	Role-play, socializing and exploration	Researchers conducted naturalistic observation, interviews, and evaluations of class	Private chat, group chat, voice chat, friends lists, guilds	Positive in-game social experiences did not transfer to the classroom.

			projects.		Negative social experiences did transfer.
Eow, et al. [30]	Develop a game	Game development	Researchers administered the Khatena-Torrance Creative Perception Inventory test	No game feature changes applied but the facilitators externally applied the Appreciative Inquiry technique.	Active learning can improve creativity outcomes, but outcomes are significantly enhanced by appropriate pedagogical support
Ke [31]	Develop an educational game	Game development in Scratch	Researchers used quantitative analysis of student-generated game code, in-field observations and interviews to determine the creative complexity of the final products.	No game feature changes applied but the facilitators externally applied Design-based learning(DBL) technique.	Children tend to focus on storytelling and personal expression rather than content integration.
Fabricatore and López [32]	Develop a game	Game development	Students completed a creativity support survey.	No game feature changes applied but the facilitators externally applied Granting developers the creative autonomy and the resources required to complete the task. Composed teams with a diversity of perspectives.	"…developing video games in an educational context recreates a work climate that supports creativity."
Robertson [33]	Develop an educational game	Game development	Creative product evaluation by an independent panel of two expert raters with experience in this research domain.	No game feature changes applied but the facilitators externally applied "Fridge Magnets," Conversation Writer, Comment Cards	Girls tend to produce more creative Adventure games due to a focus on storytelling
[21]	Game modding	Modifying the World of Warcraft UI with Lua.	Researchers performed statistical analysis of popular Chinese WoW mod databases BigFoot and WoWShell.	No game feature changes applied but the facilitators externally applied Official and unofficial web forums.	Chinese social hierarchy potentially suppressed creativity within the mod community.

Table 1: Traditional game creativity activity, outcomes, creativity features, and community observations

2.1 Discussion on Stimulating memory, problem solving, critical thinking, and creativity through games

Table 1 categorizes literature on using games to simulate creativity either in terms of playing traditional games or developing and/or modifying traditional game designs. Three major themes emerge from the review. First traditional games may stimulate or strengthen memory, problem solving, critical thinking, and creativity when integrated within curriculum or combined with supplementing pedagogical techniques. Secondly, social, demographic, or ethnographic elements within a community influence expression of creativity in by products of game activities. Thirdly, improvements in thinking skills originating from games may be transferred to the workplace. Each theme is discussed in more detail in turn below.

First, games may stimulate or strengthen creativity, problem solving, and critical thinking when integrated within curriculum or combined with alternative pedagogical techniques. Yang [28] integrated games with curriculum to stimulate problem solving, critical thinking and creativity in 11th grade vocational students enrolled in a "Store Planning and Management" class. Yang's control group used interactive whiteboards for collaboration and PC software for document creation. The experimental group used digital games-based learning and a revised curriculum that focused on critical thinking and problem solving. The Torrance Test of Creative Thinking with Pictures, a subtest of the TTCT, evaluated creativity in five dimensions: fluency, elaboration, resistance to premature closure, originality and abstractness of title. New Test of Problem Solving evaluated problem solving skills. Critical Thinking Test-Level I evaluated critical thinking. The treatment group scored significantly better across all measures, even though the control group also saw modest improvements. Eow, et al. [30] integrated the pedagogical appreciative inquiry technique with game design to strengthen perception of creative ability among 7th grade boys who self-identified as gamers. Mediated by a facilitator, the appreciative inquiry technique is exclusively driven by positive feedback at each stage in a developmental cycle. The control group did not receive any guidance beyond an online tutorial and a facilitator to answer questions regarding the game tool. The treatment group experienced the appreciative inquiry pedagogy as mediated by the facilitator. Both groups completed a creative perception inventory survey pre- and post-experience. Although both groups saw improvements, the treatment group performed much better. For measures of complacency, self-confidence, inquisitiveness, awareness of others, and discipline that may strengthen creativity, known together as the "What Kind of Person are You?" subtest, the treatment group experienced a 29% average pre to post-test improvement while the control group saw no statistically significant improvement. Eow et al shared with Yang the notion of integrating games with a non-traditional curriculum to stimulate or strengthen creativity.

Social, demographic, or ethnographic elements within a community influence expression of creativity in by products of game activities. Dickey [29] integrated play in World of Warcraft with an undergraduate game-design course. Students completed in-game tasks as part of the curriculum while Dickey observed social behavior through chat logs, e-mails and other communications and described their interactions and patterns. Dickey found that negative social experiences in a game may be disruptive to team creativity. Ke [31] noted that children participating in a math-game project tended to "focus on storytelling and personal identity or preference expression during game design" resulting in educational objectives becoming overshadowed by the students' need to express themselves. In contrast, Fabricatore and López [32] observed that students in their game development program identified many environmental factors in their experience which correlate positively with creativity, such as feeling encouraged to analyze their own work, encouragement to share ideas and possibility of assuming risks. Robertson [33] identified creative output may be influenced by alignment of the nature of the game with interests of demographic segments within a community. Specifically, in the game designer software Adventure Author, girls scored dramatically better than boys in the crafting of their games' storylines, character dialog, and choices afforded to the player. Further, girls spent more time in idea generation and conversation writing than the boys. Kow and Nardi [21] considered ethnographic influences on creativity in the context of China vs U.S. World of Warcraft "modders". Modding refers to adding or enhancing game features, rules or assets such as graphics and sound. Modding may involve simple alterations of vehicle components to complete overhauls of the graphics and physics systems. Each mod type can exercise a number of game development skills such as 3D modeling, advanced programming or creative writing. Kow and Nardi concluded that American modders scored higher than Chinese modders in terms of number of mods produced per modder, total number of mods available, and feature diversity afforded by the mods. The researchers noted that Chinese modders may have been hampered in expressing general creativity by the rigidity of their culture. Kow and Nardi noted that Chinese modders naturally formed teacher-student relationships from the outset, but due to respect of the status of the teachers, many learners failed to progress their skills or challenge the community with new mods.

Games that stimulate creativity may be subsequently harnessed and used to stimulate creativity to the workplace. Sisarica, et al. [27] created a paper-based adaptation of the Parker Brothers "Clue" that met some success in encouraging creative

thinking in caregivers who work with dementia patients. The game design helped caregivers learn creative investigation techniques, promoted closer collaboration with fellow players, and transferred those abilities into successfully generated new caregiving ideas in subsequent brainstorming sessions. In this instance, not only were players observed to be more creative after participating in the game, but vocational skills in the workplace also improved as a result of carefully balancing the game setting and themes between fantasy role-play and the workplace procedural realism.

2.2 Supplementing Games with Methods, Techniques, Interfaces & Assessment Protocols

Beyond stimulating creativity through playing, developing or modding games, games may be supplemented with methods, techniques, interfaces and assessment protocols possibly useful for creativity research. Kerne, et al. [34] describes a quantitative methodology for evaluating creativity support tools. Wegerif, et al. [35] suggests that certain kinds of creativity in online communication may be detected and classified by using artificial intelligence techniques and the resulting output used to create graphical relational maps of concepts and trends in the creative discourse. Cherry and Latulipe [36] designed a user interface evaluation framework that may be used to assess how well software supports creativity through their Creativity Support Index (CSI). The CSI categorizes user experience in terms of six paired dimensions: Collaboration, Enjoyment, Exploration, Expressiveness, Immersion, and Results worth Effort. Each category score is summed with a maximum possible score of 100. The CSI is designed for comparing different tools, comparing between different groups on the same tool, analyzing specific creative tasks within the same tool, longitudinal studies of users' development using a particular tool and other comparisons of the dimensions. The CSI is a direct descendant of Csikczentmihalyi's Flow Model inspired by the NASA Task Load Index (TLX). Like both the Flow Model and TLX, the CSI is a measure of user engagement as derived from a self-report survey [37, 38]. Unlike the Flow Model and TLX, the CSI specifically addresses dimensions of the user experience that are known to be conducive to creativity support. In addition, the CSI addresses factors from other major user experience theories such as Shneiderman's Design Principles for Creativity Support Tools, Read et al's Dimensions of Fun, and Rubin et al's Six Factors of Play as Disposition. The Test of Creative Thinking – Drawing Production (TCT-DP) is an abbreviated creativity assessment in which participants are asked to complete a picture given seemingly-arbitrary fragments (Urban, 2005). Creativity is assessed based on how the participant chose to fill in the picture, with points awarded for features like continuing lines between line fragments, drawing outside of the given box, adding symbols, or using text. The test has been shown to be well-validated and correlates well to other creativity assessments such as the Creative Behavior Inventory (Dollinger, Urban, & James, 2004). Importantly, the TCT-DP is ideally suited for online administration to a large group of people. It's quick to complete with most respondents needing no more than a half hour and can be adapted into a web application for easy administration via social media channels and game forums frequented by the players.

2.3 Stimulating & Sustaining Creativity through technology Builder games & Gaming Meta-Communities

The emergence of recent "builder" games and concurrently self-directed gaming meta-communities appears to be a venue to stimulate, strengthen, and possibly sustain memory, problem solving, critical thinking, and creativity. *Minecraft*, *Space Engineers*, *Robocraft* and *Beseige* represent a technology "builder" class of online games that attract large numbers of self-directed individuals to engage in construction of technological objects (vehicles, robots, structures) in a dynamic virtual environment. [39] consider "builder" games evolutionary successors to physical Lego construction kits. Beyond the traditional directed integration of games within defined community structures, "builder" games engender emergence of communities around them. Though the same may be said of online games such as *World of Warcraft [40]*, the new *Minecraft*, *Space Engineers*, *Robocraft* and *Beseige* genre of games is distinguished from *World of Warcraft* game genre and even established sandbox games like *SimCity* by a focus on constructing or building technological objects. Designer-imposed narratives or goals give way to freer exploration and interaction with the environment resulting in a engaged, enthusiastic player community with prolific creative output. From a science and technology perspective, *Minecraft* is particularly noteworthy due to the acquisition of its development company, Mojang AB, by Microsoft for 2.5 billion dollars [41]. One Mojang AB game, *Kerbal Space Program* (KSP), may be of interest to technology education. KSP features a robust vehicle design software that enables one to build a countless variety of spacecraft from hundreds of spacecraft parts. The KSP community has a thriving social media presence – 86,000+ subscribers on the Reddit subreddit /r/KerbalSpaceProgram, 7,400 subscribers on subreddit /r/KerbalAcademy [42], and about 800,000 videos posted on

YouTube [43]. The KSP community currently publicly shares about 700 vehicle designs [44] and over 300 modifications to the game itself [45]. Segments of the educational community may leverage builder games and KSP in particular for more directed stimulation of creativity. For example, notionally students may create spacecraft in KSP and simulate flight in the KSP environment that provides a basic aerodynamic model and patched-conics interplanetary dynamics model [46]. Given a backdrop that globally the average U.S. score ranked 29th out of 65 participating countries in science literacy [47], stimulating interest in science and technology creativity through games such as KSP may not be so far-fetched. Ethnographic questions remain a concern as Proctor and Marks [48] indicate U.S. K-5 exemplar educators are more receptive to games in the classroom than U.S. 6-12 exemplar educators. Further, high school graduates may be more receptive to games for serious applications than college graduates [49].

3. Conclusion, Limitations, and Recommended Future Research

Recent literature supports the notion that traditional games may stimulate or strengthen memory, problem solving, critical thinking, and creativity when integrated within a curriculum or combined with supplementing pedagogical techniques. Creative outcomes from traditional game activities may be either positivity or negatively impacted by social, demographic, or ethnographic elements within a community. With skilled design, improvements in thinking skills originating from traditional games may be transferred to the workplace. Games may be supplemented in order to gather feedback possibly useful for creativity research but these mechanisms remain either relatively new or a work in progress. Limiting the generalization of the fore mentioned conclusions is that the contribution to stimulating creativity arising from the game may be confounded with other variables such as community, instructor technique, communications, etc. Additionally most researchers emphasized qualitative assessment of creative outcomes with [22, 30, 50] being noted exceptions who emphasized quantitative measures.

This review suggests that researchers and educators engaged in investigating stimulating creativity in fields of science and technology consider Minecraft, KSP, or similar games as potential creativity research venues. For technology, the scope and proliferation of creativity seen within builder games and the phenomenon of emergent online communities gives rise to questions similar to those posed earlier. Do “builder” games stimulate creative thinking or harm creativity? And if they do stimulate creativity, what is the value of the creative outcomes? What features of a builder games like *Minecraft* and KSP stimulates creativity? Do the builder game online meta-communities contribute to creativity? If these non-traditional gaming venues are an opportunity to stimulate, strengthen, and even sustain science and/or technology memory, problem solving, critical thinking, and creativity, how and to what degree? Is creativity stimulated within the game environment transferable to related fields of endeavor? If so, which ones? If builder games do stimulate creativity beyond gaming itself, within the educational hierarchy, what level of education makes the best fit? What educational fields? Given that the current player communities are composed of self-selected participants that may behave differently than members of other communities, will creative outcomes observed among a self-selection community transfer to other communities?

The Cherry and Latulipe [36]’s CSI and Urban [51]’s TCT-DP are protocols that may assist in investigating the fore mentioned questions. The CSI cannot alone determine the extent to which games or specific features contribute to creativity but the CSI quantitative measures may identify exemplars that may serve as models for future educational games that promote creativity. Secondly, measuring the creativity of existing players may help establish a correlation between time spent either in the game or in the community as well as with creative achievements in the games or related technology fields. The TCT-DP may be considered an appropriate quantitative measure that may be administered to a broad sample of community players while achieving measuring the creativity of existing players. Both research objectives may be addressed by a voluntary online survey package (posting on social media, game forums, etc.). Levels of participation and statistical methods will be critical to assessment outcomes.

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