MOTIVATIVE COMPUTING: AN INTERDISCIPLINARY ANALYSIS AND DESIGN FRAMEWORK

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ABSTRACT

Competition for funded research continues to tighten around the globe with awards granted to higher impact projects. While sharing of ideas generally occurs in pockets, it becomes crucially necessary to advance collaborative engagement among researchers. At a growing research university, interdisciplinary methods were applied to gain deep understanding of the scholar's world and to develop an engaging platform for collaboration. User-centered design, systems analysis and design, object-oriented analysis and design, and psychology theory facilitated a multidimensional view of the problem domain. A critical finding revealed that faculty did not know about the skills, knowledge, and interests of others across campus. Curiosity, honor, and idealism were found to intrinsically motivate researchers that provided an empirical basis for creative design.

Analysis findings, along with aesthetic and game elements, informed a solution designed to energize and direct self-determined participation—elements missing in classic systems development processes. Scholar Trading Cards™—the locus of purposeful and serendipitous interaction—mobilized researcher acumen in digital and non-digital spaces. Digital card data published on the university Intranet allowed for searching and sharing of information useful to collaborators, administrators, and staff. Paper-based cards facilitated face-to-face interactions. The platform is showing promise in bridging interpersonal gaps to improve the flow of scholar information across campus. We introduce a contemporary systems framework and information platform that is demonstrating a positive effect on campus-wide collaboration.

KEYWORDS

Systems, collaboration, psychology, motivation, games, interaction.

1. INTRODUCTION

Competition for research funding continues to plague scientists, with no relief in sight (Howard & Laird 2013). Shrinking grant awards in nationally supported programs, along with flat public and private sector money, leaves researchers feeling discouraged and some programs at risk. The scientific community and university administrators recognize that traditional models are ineffective in keeping pace with fiscal limitations and continue seeking alternate means to sustain external research (Howard & Laird). Collaborative proposals along with improved communication and networking are among the growing strategies needed for success in funded projects.

Amid global tensions for research survival, Rochester Institute of Technology (RIT) increased faculty requirements for scholarship, namely externally funded research. Of the many challenges encountered in the

multi-year transition, collaboration−a critical success factor−was found to occur in pockets highlighting the problem of weak collaborative pathways. At the time, gamification–the use of game elements in non-game contexts (Deterding, et al. 2011, p. 2)–was touted as a bellwether to energize and direct volitional behavior (Hamari, et al, 2015). Recognizing a parallel between volitional engagement in games and collaboration this research emphasized the need to understand more about what motivates researchers.

Funded by RIT's Sponsored Research Services, the overarching goal of this research project was to improve interdisciplinary collaboration (interaction between people or organizations directed toward a common and mutually beneficial goal (Miner, et al. 2011)). We approached the problem of weak collaborative pathways using the Methodopoly™ analysis and design framework. Methodopoly™ evolved from a previous study (Gears & Braun 2013) that considered motivating factors of key players to solve a business problem. We extended that framework more formally in this research by designing a framework that integrates interdisciplinary methods, psychology, game design, and aesthetic elements, with creativity during analysis and design (Deterding et al. 2011).

Our study addressed four research questions: 1) Are there common intrinsic desires among researchers that can be used in systems design to motivate engagement? 2) Can a solution using the Methodopoly™ framework be designed to engage volitional participation and increase collaboration? 3) Can the inclusion of game elements in a goal-oriented user-experience be taken seriously by a research community? 4) Will the solution result in increased scholarship (grant proposals and awards, publications, and increased graduation rates for thesis-bearing degrees)? In this paper, we will introduce the Methodopoly™ framework, our solution, and the results of our work still in-progress.

2. THEORETICAL FOUNDATIONS

Energizing behavior through motivation design has demonstrated prolonged behavioral engagement and achievement of desired outcomes (Rigby 2014; Rigby et al. 2011). A study of employee behavior in an open enterprise wiki (a socially open technology facilitating collaborative content development and information sharing) (Gears, 2011) highlights the role motivation (an internal state, need, or desire that energizes and directs behavior (Deci & Ryan 1985; Reber & Reber 2001; Reeve 2005)) plays in contextually-bound collaborative environments (Gears 2012; Gears 2011). Two motivation theories guided understanding of psychological factors prompting wiki participation; positive and negative affect (emotion) were also found to be predictors of engagement (Rigby 2014; Rigby & Ryan 2011; Ryan and Deci 2000). The Theory of 16 Basic Desires contributed to understanding the innate human desires of individuals. The Self-Determination Theory (Deci & Ryan 2000; Deci & Ryan 2011) identified internally regulated action along a spectrum of extrinsic and intrinsic motivation. Collaborative engagement patterns describe contextual conditions, emotions, and motivational elements that contributed to positive and negative participation behaviors (Gears et al. 2013).

2.1. Theory of 16 Basic Desires (Sensitivity Theory)

The theory of 16 basic desires (Reiss 2004, 2000) a psychological content theory of motivation, provided utility for analyzing and predicting human behavior. Reiss' model, derived from Maslow's (Maslow 1954) theory of human needs, and William James' (James 1950) theory of internal desires, describes basic desires for: Order, Power, Independence, Curiosity, Acceptance, Saving, Idealism, Honor, Social Contact, Family, Status, Vengeance, Romance, Eating, Physical Activity, and Tranquility. The manner in which humans act upon these desires is shaped by the intensity of each desire, cultural influences, and individual experiences. An individual's intensity for each of the 16 basic desires can be measured using Reiss' Profile of Fundamental Goals and Motivational Sensitivities Assessment (Reiss 2000).

2.2 Self-Determination Theory (SDT)

The self-determination theory (Deci & Ryan 2000, 1985; Ryan et al. 2000a, 2000b) framed a motivation model that explains what and how human behavior is initiated and regulated (Deci et al. 2000; Ryan et al. 2000a, 200b). The SDT recognizes social and environmental conditions that affect personal volition and engagement in activities. The SDT combines both content (psychological needs) and process (cognition) motivation

describing needs for autonomy, competence, and relatedness. An individual's motivation for action is defined along a spectrum of amotivation, extrinsic motivation, and intrinsic motivation measured by perceived locus of causality (external to internal regulation). Needs for autonomy and competence allow the "prediction of the social circumstances and task characteristics that enhance versus diminish intrinsic motivation" (Deci et al. 2008, p. 233).

Quality of extrinsic and intrinsic motivation contribute to explanations for why individuals engage (Rigby 2014; Rigby et al. 2011). The SDT also describes psychological principles in gamification design that sustain user engagement, satisfaction, and behavioral change. In gamification design, goals are not necessarily directed towards the experience of "fun," rather goals are more closely related to personal value and avoidance of pressure and control (Rigby 2014). Deep understanding of the psychological needs of individuals is deemed necessary to motivate desired outcomes (Rigby 2014).

2.3. Collaborative Engagement Patterns (CEP)

In a study of corporate wikis (Gears et al. 2013), four collaborative engagement patterns explained contextual conditions and internally regulated psychological factors contributing to wiki participation decisions. When required by managers, projects, or teams, *Conformists* interacted (lurk, add, minor edits) when required by their managers, a project or team—emotions changed from negative to positive (liking the wiki) and positive to negative (because interaction was required). *Embracers,* initially experiencing negative emotions interacted (lurk, add, edit, explore) when their manager shared a positive attitude and offered time to explore. *Collaborators* actively interacted (lurk, add, edit, collaborative content development, wiki discussions) describing perceived value [of the wiki], confidence in appropriate interactions of others (corporate conscience), and positive affect. *Traditionalists*, deeply rooted in a traditional corporate culture, expressed negative affect and would not change other employees' words in the wiki. These patterns provide empirical evidence of technology facilitate collaboration inside organizational boundaries.

3. ANALYSIS AND DESIGN APPROACH: METHODOPOLY™

Classic systems development processes lack explicit inclusion of interdisciplinary methods that address emotion, motivation, artistry, and creativity. Considering the upswing in web-based information systems and the competition for participation in social platforms, we tested the Methodopoly™ framework designed to energize and direct (motivate) participation. Formal methods (user-centered design, structured and object-oriented analysis and design) and psychology theory (motivation and emotion) were integrated synergistically with game design, visual arts, and creativity. The framework depicts an interdisciplinary, iterative, incremental, and improvisational analysis and design framework (refer to Figure 1). Formal methods were applied in concert with analysis of the data (study hall), design ideation (visits to the drawing board), collaboration (collaboration corner), and resting the mind for creativity (take-a-walk). Methodopoly™ was not partitioned in phases or executed in sprints. The step-by-step model allows team members to take two steps forward and three steps back; budget, schedule, and final decisions left to the principal investigator.

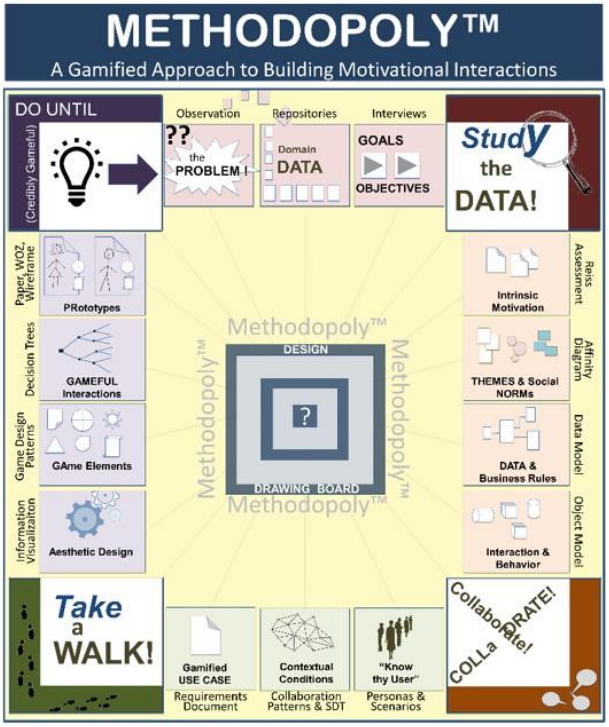

Figure 1. Methodopoly Framework

3.1. Analysis Activities

Study participants (24 researchers), varying in research abilities and experiences, working in different disciplines, were selected through purposive sampling. Researcher experience ranged from "interested in research, haven't done much and need to", to "significant, research has been my career." Qualitative methods were applied where participants were interviewed in their working environment. Analysts captured descriptive (record of details) and reflexive (subjective reflections) (Bogdan et al. 2003) field notes from interviews and observations.

The Reiss Motivation Sensitivities Assessment (Reiss 2000) was administered to all participants through an anonymous web-based instrument. The survey replicated Reiss' protocol to assess intensity of the 16 basic desires that motivated each researcher. Data were analyzed in the aggregate (refer to Figure 2).

Structured and object-oriented methods, collectively known as software engineering, e.g., data, process, object, sequence, state diagrams, logic models, etc., were integrated to flesh out requirements and for design (Constantine et al. 1999) . User-centered design (from human-computer interaction discipline) were also applied to gain deeper understanding of researcher needs, wants, personas, and contextual conditions. Synergistic application of methods and study of the data facilitated a deep understanding of the domain necessary to test the boundaries of what could be possible in design (Coleman, 2005).

Table 1. Excerpt of findings

Business/Institute Problems
• Weak collaborative pathways • Research skills vary across institute • Student and external involvement a lost opportunity • Difficult finding faculty and students to work with • Departmental silos interfere with collaboration • Sharing takes effort when domain language not understood
Researcher Norms
• Like to share and expect acknowledgement for their work • Prefer to choose with whom they collaborate • Very busy with limited direct contact availability
Business Rules
• Researchers may be faculty or students • Faculty are expected to, and evaluated for, their research • Research requirements vary by faculty position • Researchers may be associated with many affiliations

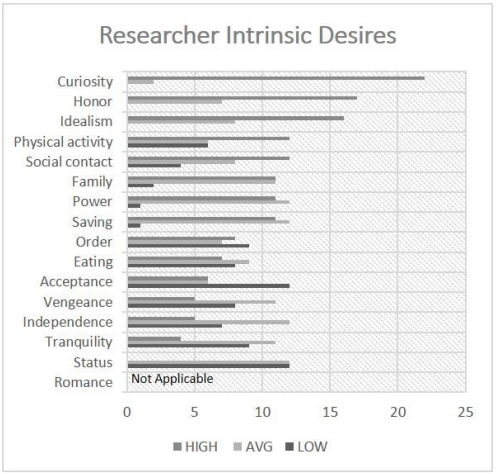

Figure 2. Researcher Intrinsic Desires

Interpretation and field notes taken from interviews provided a basis for card sorting and affinity diagramming (Holtzblatt et al. 1997)—revealing key themes in the data (refer to excerpt in Table 1). Personas and user scenarios mapped actor characteristics, behavior, expectations, processes, value perceptions, and more.

Participant's intrinsic motivational tendencies were analyzed along the continuum of the 16 basic desires described by Reiss (2000). Data indicated that *Curiosity* (the desire to explore and learn) ranked highest on the motivational spectrum for all researchers. *Honor* (the desire to be loyal and a credit to ancestry) and *Idealism* (the desire to make the world a better place) followed and were also highly scaled with no desires for avoidance (low importance). Acceptance, Tranquility, and Status ranked low indicating they held little motivational value. Refer to Figure 2 for distribution of all 16 basic desires.

Analysis findings were aligned with research questions and use cases were created to include goals and objectives for the system under study. Based upon factors that enable collaborative engagement in organizations (CEP), pre-conditions included the need for egalitarian governance, time for participation, value proposition, and conditions that would not affect pay or performance measures, to create an environment conducive for community engagement.

In parallel with analysis, we studied an array of game design elements (Bjork et al., 2004; Burke, 2014; McGonigal 2011; Reeves et al. 2009; Ryan et al. 2000a; Schell 2008; Werbach et al. 2012) throughout analysis and design. A shared understanding of game elements—their behavior, use, and parameters—provided a common language for discussion and mental bookmarking of game-oriented building blocks. We wanted to

build on the positive aspects of game play (without delivering a game) by leveraging known motivational tendencies that might prompt action.

3.2. Design Activities

Platform design involved recursive study of the data, functional design proposals, and evolution of analysis models to design models. We studied characteristic of intrinsic desires wondering how, when, and where they could be leveraged to pique (and sustain) curiosity, and invoke feelings of honor and idealism (Reiss 2004; Reiss 2000). We studied scaling of extrinsic motivators described in the SDT (Dec et al. 2000; Rigby 2014; Ryan et al. 2000a) searching for means to foster feelings of autonomy, competence, and relatedness. Motivational characteristics, game element conditions, and contextual study data weaved through our thoughts throughout design.

To clear our mindset from reality and shift to possibilities of invention we deliberately transformed our thinking about system objects e.g., Employee, College, to *Players* and *Playing fields*. This facilitated a more open flow of design ideas during joint application design sessions and independent reflection. A project wiki facilitate sharing of design ideas when they were sparked by individuals. Visual effects and prototypes facilitated the acting out of complex design concepts. Design ideas were play tested with the research community and helpful in dispositioning, i.e., throwing out or building up.

Over time, a feasible design solution emerged and provided a basis for momentum to build in system design. The entity relationship diagram then served as a central design model for connecting use case interaction rules, constraints, and system data. All requirements and design specifications were collectively documented in *gamified* use cases. Each use case indicated actor behaviors, values, beliefs, contextual norms, data, rules, constraints, game elements, motivators, contextual conditions, and normal course of interaction.

3.3. Creativity

Wallas' (1926) four stages of creativity were explicitly called out as the anchors to the novel combination of structured methods, domains and disciplines. The Preparation stage served to demarcate and clarify the problem statement through immersion: gathering approaches and collaborating with others. Frequent walks and time away from the problem itself facilitated a period of unconscious and involuntary Incubation where new patterns and insights were generated. Potential ideas emerged in the design space: some like flashes of insight, others like progressive bytes of knowing (Wallas; Czikszentmihalyi 1996). These were the "aha's" of the Illumination stage. The building of physical prototypes tested the validity of the problem solution in the Verification stage.

Czikszentmihalyi (1996) suggested that the creative process is more recursive than linear, requiring multiple iterations, loops, and insights. Both the genesis and attributes of Methodopoly™ paralleled this recursive nature. While the design process portrays a simplified organization of the numerous methods used, the game play was designed to "Do Until" a credible and gameful solution was completed.

3.4. Approach Summary

An unscripted process framework–Methodopoly™ guided synergistic application of interdisciplinary methods for systems analysis and design. Brainstorming of design ideas (Schell 2008) focused on means to energize intrinsic motivators of curiosity, honor, and idealism found to motivate scholars. User-centered design, structured, and object-oriented methodologies, motivation psychology, game design, and aesthetic design were linked through creativity. A plausible design solution emerged following an improvisational sequence of action directed by the Principal Investigator.

4. SOLUTION

Scholar Trading Cards™ were implemented as the locus of intrinsically motivated interaction in digital and non-digital spaces. Pocket-sized to emulate historical sports artifacts, card fronts featured a professional photo,

QR code for digital sharing, contact information, and a campus-wide tie strength indicator. Card backs highlighted credentials useful in finding collaborators: academic degrees, skills, domains, research interests, research methods, affiliations, fun facts, publication keywords, and a trending moniker (refer to Figure 3).

The *Scholar Trading Card*™ is directed at researcher's (scholar's) intrinsic desire for Honor—incentive to feel pride, meaning, and self-worth (Epley 2014; Reiss 2000)—and Idealism—motivation to get involved and contribute to the betterment of the academic community by attending to the significance of what they do (Epley 2014; Reiss 2000). A web-based platform facilitated digital manipulation (tap and transfer of cards) by viewing (flipping), searching, and collecting cards. This appealed to the intrinsic desire for curiosity (explore, learn, and analyze information). Printed (touch and trade) cards allowed free-play with known and unplanned uses. Students, faculty, staff, and alumni had the freedom to participate and feel part of the academic community (autonomy & relatedness.)

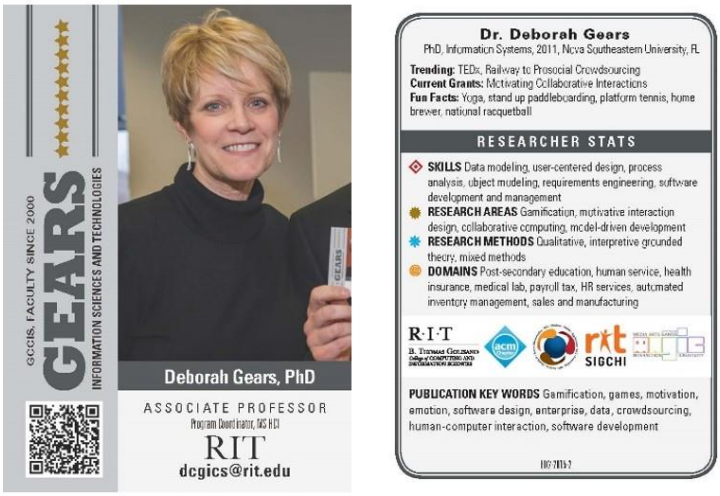

Figure 3. Scholar Trading Card Example (front and back)

A Dedicated Facilitator assisted scholars with development of their card content due to scarcity of researcher time (CEP) and inability of most researchers to succinctly articulate key accomplishments. Content patterns were based upon scholar personas (developing researcher, practicing researcher, established researcher), department colors (reflection of Honor to the university's academic discipline), along with unique professional or personal attributes.

Each new card owner received a limited number physical cards to distribute as desired; the digital card was immediately published to the web upon scholar approval. According to the Law of Scarcity (Hogan, 1998), the value of physical cards will increase over time given limited supply in circulation. Additional physical cards were earned by growing the network through scholar referrals, scholar card acquisitions, special events, and more. In alignment with Hamari, et al. 2012, we found that users found their own value for the cards. For example, academic advisors allow students to add digital cards when recommending faculty to put a face to a name.

Any digital card could be added to a user's collection of cards directly through the web or by scanning the QR code on a physical card. Collectors were asked about their connection to the scholar to analyze effectivity in bridging structural holes (Burt, 1992) and social network growth over time. "How do you know a scholar?" questions were directed at quantity of interactions, not quality of a relationship. For example, card acquirers must indicate their tie-strength as the final step in card acquisition: 1) Never interacted, 2) Been introduced, 3) Interacted with infrequently, and 4) Frequently interacted with.

Card design focused on brand recognition, presentation of information, and appeal to intrinsic motivators. Integrating color and contrast according to Gestalt Theory (O'Connor 2005) provided structure and consistency for visual perception of information (O'Connor). The combined selection of typography, color, contrast, proportion, and balance contributed to a coherent and comprehensive design (O'Connor; Tufte 1990).

The study of game elements (indicated in italics) in games provided a thought-provoking pallet of discrete building blocks used to gamify the user experience. According to Bjork, et al. (2004), cards were considered

memorabilia for *social interaction* allowing for *gain ownership*, *collecting*, *reward, and game element trading*. New players experience *player created game elements* when, with the help of a *dedicated game facilitator,* they create their card. *Unnecessary obstacles* (McGonigal 2011) were inserted to provide some level of challenge leading to a sense of competence. Rules governing the use of physical cards were left open for opportunistic and serendipitous interaction.

5. RESULTS

The *Scholar Trading Card*™ platform was deployed in grassroots fashion beginning with one small group presentation (approximately 50 faculty, staff, and students), a digital briefing in the daily university news, and word-of-mouth exchanges. Ten printed digital trading cards were play tested for a period of three months while web development and design continued. During the play test period, the number of new scholar cards increased to 30 published cards representing an estimated 6% of research faculty. Serendipitous uses for the cards are also surfacing among students, staff, and faculty.

Early indicators suggest that the inclusion of game elements in goal-oriented systems design can be taken seriously by a research community (research question 3). Engagement (types of interaction with the digital system) included: card requests, face-to-face card exchanges (metrics unknown), website views, digital cards collected, and referrals. Over a nine-month period dating from late November 2014 to late August 2015 (including three academic break months), a total of 51 cards have been requested, with 261 unique users, and 650 views.

A measure of tie-strength indicated that 136 digital cards were added to individual collections between May 2015 and August 2015. Of the digital cards collected, 40% were made among people who had *Frequently Interacted*, 29% among people who had *Been Introduced*, 26% among people who had *Infrequently Interacted*, and 5% who had *Never Interacted*. Increases in scholarly activity (rises in grant proposal, awards, publications, and graduation rates for thesis bearing degrees is not know at this writing (research question 4). Longitudinal data collection be collected over time to measure the impact on scholarly activity among the research community.

6. CONCLUSION

Systems development projects involving motivation psychology, game elements, and creativity, go beyond the phased borders of traditional systems development lifecycles or agile development. This research introduced a framework, Methodopoly™ that resulted in a platform designed to improve weak collaborative pathways. Interdisciplinary building blocks were called upon when needed to understand the user's world, leverage motivating factors of key players, test organizational boundaries, and to create an environment that fostered volitional participation. Early results demonstrate an increase in user connections across a university campus.

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