Considering Patterns of Creative Work Process in Creativity Support

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ABSTRACT
This is a workshop position paper submitted to the Evaluation Methods for Creativity Support Environments workshop at CHI 2013. This paper presents basic, low level models of extended creative work process and proposes that these be taken into consideration in creativity support environments.

Author Keywords
Creative process, creativity, innovation.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Human Factors; Design; Measurement.

INTRODUCTION

This paper presents basic, low level models of extended creative work process and proposes that these be taken into consideration in creativity support environments. From 2010 to 2012, we undertook a comparative case study of the work practices of nine successful creative practitioners: three working in computers science, three in engineering, and three artists working with technology as a medium. These practitioners were pursuing their projects on their own accord in the course of their professional work without orchestration for study or academic purposes.

We collected data on our subjects' work practices through a series of weekly semi-structured interviews over the course of four months to a year, depending upon their project timelines. We observed and recorded work sessions and meetings, and documented artifacts related to their projects such as notes, tools, technologies, prototypes, and information sources. We read texts our subjects indicated were important to them and discussed these texts with them. We tracked their creative process over time, constructed detailed diagrams of their work practices, and then used these diagrams to elicit their clarification. Our subjects also reviewed drafts of our case reports and commented. We transcribed, organized, coded, and analyzed the data for patterns.

The case study methodology is particularly useful in establishing grounded-in-evidence descriptions of how or why phenomena occur in real-life contexts. As is well-established in the literature of qualitative methodologies [4, 6], case studies generalize to theory as opposed to attributes of a population. We will not be reporting statistical outcomes such as "Engineers use this creative strategy while artists use that creative strategy." Instead we use our concentrated lens to name and articulate patterns of phenomena in play within these arenas of creativity and innovation.

CREATIVE PROCESS MODELS

We observed and identified two distinct, recurring, patterns of creative process in our subjects' work practices. We named these patterns *teleological* and *stochastic*. The overall creative processes we observed in our subjects were typically sequential combinations of these basic two patterns.

Teleological and Stochastic Creative Processes

Teleological is a term we borrow from philosophy. A teleological process exists for a specific end or final cause. The near-oxymoron "final cause" is descriptive. Teleological processes specify a clear end goal at the beginning of the project. In the cases in the disciplines that we investigated, this end goal typically took the form of a detailed design. In the initial stages of the teleological process, this design is formulated and then projected forward in time to the end state, from where it drives and constrains the intermediate process between the initial and end states. It is the final cause of the process. See Figure 1 for a conceptual diagram.

Teleological creative processes are end-driven processes. The process is constrained to solutions that conform to the final cause. Deviations are discouraged. Emergent work is checked against the final cause as a terminal reference, and is iteratively refined to match this reference as closely as possible. As practitioners face and resolve intermediate problems, they come to a deeper and more detailed understanding of the final cause that they constructed.

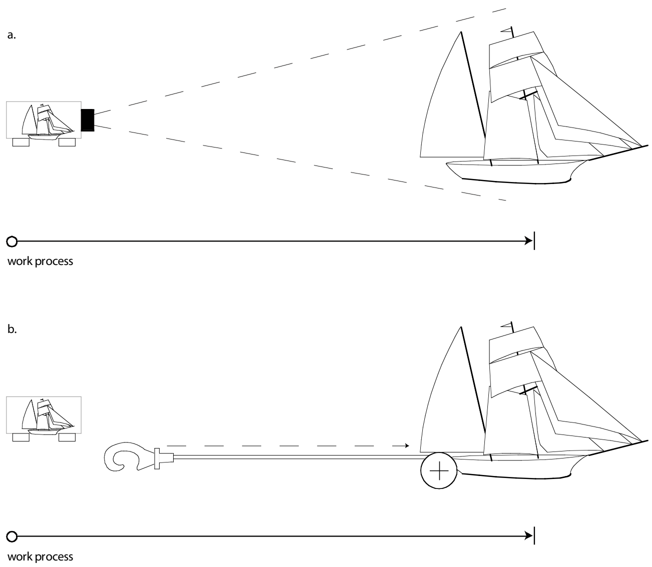

Figure 1. Conceptual drawing of a teleological process. (a.) A detailed design is projected forward from the initial stages of the process to the end state, from where it (b.) pulls, directs, and constrains the process.

Contrast this with a *stochastic* process. *Stochastic* is a term from probability. Stochastic processes are non-deterministic, even when they depend upon initial conditions and are constrained within a subset of resolutions. Stochastic processes have a completely different relationship to the end state than teleological processes. They do not function by fixing the final form of the project early in the process. Instead, the form emerges through a nondeterministic walk through a space of possibilities. The walk consists of multiple steps or decision points, each presenting multiple potentials. These potentials can be experimented with before a way forward is chosen. This allows know-how and experience in the project domain to be developed along the way. Project experiences, even paths not ultimately taken, may feed into the final form. See Figure 2 for a conceptual diagram.

On a local scale, a stochastic process can appear as a series of random moves, but from a global view, constraints can be found that encourage the process to converge to a design. These constraints are often more covert, less codified, and less articulated. They might not be overtly obvious, even to the practitioner, or they may become obvious in hindsight. This is the nature of intuitive work. Constraints are often hidden in project metaphors or experiential aspects.

Consequences of Teleological and Stochastic Processes

Teleological processes have the benefits of predictable progress toward a predetermined end goal. The probability of successfully meeting project requirements is maximized. Resources can be optimized, as can the safety and reliability of the solution. Teleological processes support stable communication between team members, and the ability to communicate a vision of the final solution to stakeholders at an initial stage in the process. Overall, teleological processes reduce the uncertainty associated with a creative project.

Teleological processes require as much complete knowledge related to the project as possible in the beginning stages. In other words, teleological processes frontload the knowledge necessary to complete the project. We see this in the typical construction of engineering education, where students are required to take years of coursework before their final capstone project. Contrast this to the construction of art education, where students learn their craft through ongoing repetition of creative project work and few lectures.

In our study we found that the exploratory nature of stochastic work can lead to emergent, novel, and breakthrough designs. The tradeoff is that stochastic processes carry more uncertainty than teleological processes. Practitioners must weather the vagaries of a nondeterministic creative process. In our study, the practitioners who typically employed stochastic processes relied upon a well-developed, internal compass of authenticity that lent assurance to their decision-making within ambiguous and indeterminate creative conditions. This internal compass and self trust was developed through their personal experience with stochastic processes. For a more in-depth discussion of the relationship between teleological and stochastic processes and the uncertainty inherent in the creative process, please see [2].

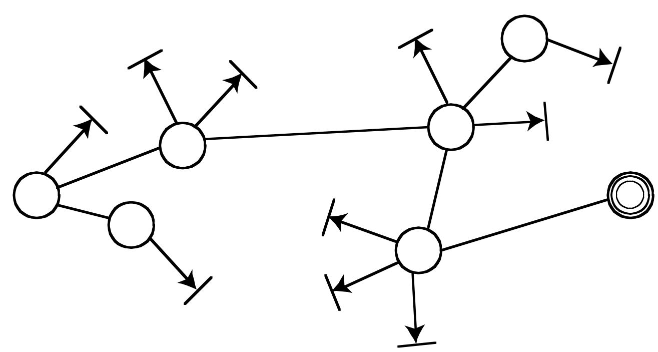

Figure 2. Conceptual diagram of a stochastic process. Multiple steps or decision points (represented by circles) each present multiple potentials (represented by lines) which converge to a design (represented by the concentric circles).

BRIEF EXAMPLE

As we mentioned above, in our case study we typically found combinations of teleological and stochastic processes at work within a single project. One of our case projects began with a U.S. Defense Advanced Research Projects Agency (DARPA) request for an e-textile garment with special capabilities for monitoring a soldier's condition in real time from a base station. These capabilities included vital signs monitoring, identification of if and where the garment had been punctured, and signal transmission. The engineer began the initial ideation stage of the project by articulating the necessary requirements of the garment, such as connectivity, durability, usability in combat, manufacturability, and maintainability. These requirements unpacked into a subset of related requirements. For example, usability in combat implied thermal protection, resistance to petroleum products, and minimization of signal detectability. These requirements were reorganized into five concepts for the design, i.e. penetration-sensing, electrical-conducting, comfort, form-fitting, and static-dissipating. These concepts translated directly into a model for the structure of the textile. Specific materials were chosen using a weighted prioritization matrix. A Quality Function Deployment engineering process [1] helped the engineer and his team finalize a design that maximized their chance of producing an effective garment for the combat scenario.

The creative strategy of the engineering team harnessed knowledge, know-how, resources, and systematic decision-making to ensure the success of the project. Bringing together appropriate technological elements in a reliable and safe way is a highly creative process. The engineers leveraged their accumulated knowledge at the initial project stages in order to develop a clear strategic intent and ensure that the final product would pass a public test of satisfaction, safety, and reliability. The desired design outcome was projected forward to the end state where it guided the project throughout all subsequent stages.

The engineers proceeded toward this desired outcome while constantly checking the emergent work against it as a reference, iteratively refining the work to match this reference as closely as possible. As the engineers faced intermediate problems and resolved them, they came to deeper and more detailed understandings of this reference.

This teleological process served to stabilize as many parameters as possible and constrain additional potentials and deviations. It allowed the engineers to focus on optimizing solutions for their requirements in order to weave together technical materials to produce a high-functioning product…until a series of intermediate problems arose.

Many of the samples the engineers used for testing and proof of concept were produced using a standard table loom and hand techniques. In order to ensure the connectivity of the conductive fibers in the final garment, novel weaving methods and connection techniques had to be invented for both prototyping purposes and future manufacturing. During the fabrication stage, certain impasses led to bursts of creative energy searching for and trying multiple options that in turn led to previously unknown solutions. The successful solutions were then refined.

For example, the insulation on the conductive fibers was scraped by hand to create connections between fibers in the test samples. A more automated process had to be designed for larger scale production. Ad hoc experiments with multiple common items at hand led to a process involving nail polish remover to dissolve the insulation and a vibrating toothbrush to then thatch the conductive fibers together. This process evolved into a novel system for forming electrical junctions in textiles using a solvent and ultrasonic excitement, which the team eventually patented.

It was during this stochastic period of project work that the overall project metaphor was refined. On a conceptual level, the engineers had been inspired by a computing metaphor during the initial, teleological phases of designing the cloth. They thought of the cloth as a weave-able, wearable, elastic computer. This metaphor guided the project through the teleological stages preceding the impasse described above. While the team was working toward solutions in a more stochastic way, the engineer had an "aha" moment:

Today I might want to monitor my heart rate. Tomorrow I might want to talk to my shirt. So I said to myself, where do I look for a solution that is ubiquitous in terms of providing flexibility and I can still remember that day…I looked out at {anonymized} and I said, "Wow, it's a motherboard. It's a computer motherboard." A computer motherboard gives you the flexibility of plugging in whatever chip you want.

Realizing the project as a wearable computer motherboard reframed the project. This new metaphor emphasized the flexibility and modularity of the design and enabled the team to see possibilities for attaching various devices to the garment, with the textile acting as a motherboard. This led the team to consider multiple "plug-and-play" applications beyond combat casualty management. The garment could support components with functionalities important to athletes, home care patients, firefighters, or astronauts. A consumer version could allow components to be interchanged according to need or desire. The team did create a robust and innovative garment for monitoring the condition of soldiers, but the stochastic phase of the project led to an "aha" moment that reconfigured the project away from the initial goal toward creating a flexible sensate textile that could be used for a spectrum of applications. This ultimately led to a much larger collection of patents related to the project and the eventual licensing of the stochastically-conceived technology.

CONCLUSION

Through our descriptions and a brief example, we hope to have illustrated the teleological and stochastic models of creative process. Teleological and stochastic processes have different relationships to the end state of the project, knowledge practices, and negotiating the uncertainty inherent in the creative process. While we ourselves are not very familiar with the domain of creativity support environments, it is our hope that the original research presented here can contribute to the understanding of how to support creative practice. In turn, we look forward to learning more about the creativity support domain.

ACKNOWLEDGMENTS

The pilot case study research for this project was originally funded through the CreativeIT program of the U.S. National Science Foundation (NSF), grant 1002820. The engineer whose work is presented in this paper has waived anonymity so that his work could serve as an example. For further information on his process and the resulting technology, please see [3, 5].

REFERENCES

1. Akao, Y. 1990. *Quality Function Deployment*. Productivity Press, Cambridge, MA.
2. Fantauzzacoffin, J., Rogers, J.D., and Bolter, J.D. 2011. Negotiating Uncertainty: Process, Artifact, and Discourse in a Case Study of Technologies to Address SIDS. In *Proc. of the Second International Conference on Creativity and Innovation in Design* (DESIRE 2011). ACM Press, New York, NY.
3. Gopalsamy, C., Park, S., Rajamanickam, R., and Jayaraman, S. 1999. The Wearable Motherboard™: The First Generation of Adaptive And Responsive Textile Structures (ARTS) for Medical Applications. *Journal of Virtual Reality*, 4, 152-168.
4. Miles, M.B. and Huberman, A.M. 1994. *Qualitative Data Analysis.* Sage Publications, Thousand Oaks, CA.
5. Park, S., and Jayaraman, S. 2001. Adaptive and responsive textile structures (ARTS). In *Smart Fibers, Fabrics and Clothing*. X. Tao, Ed. Woodhead Publishing Limited, Cambridge, U.K.
6. Yin, R.K. 2008. *Case Study Research: Design and Methods*. Sage Publications, Thousand Oaks, CA.