Interdisciplinary Collaboration in Digital Media Arts: A Psychological Perspective on the Production Process

Brigitte Steinheider and George Legrady

ABSTRACT

The complexity of digital media technologies requires artists to form teams of specialized experts integrating their contributions. Studies on interdisciplinary collaborations in organizational and scientific research-and-development teams have revealed that three processes—communication, coordination and knowledge-sharing—significantly influence their efficiency and effectiveness. This model was applied to an international and interdisciplinary digital media art production team to analyze the effects of team members' geographical dispersion, differing nationalities and heterogeneity of disciplines. The results are in accordance with previous studies of teams in corporate and scientific settings but also reveal differences between artistic and industrial product development processes.

Interdisciplinary teamwork has become increasingly common in industrial and knowledge development, most recently in the field of digital media art practice, where the complexity of technology has caused a shift from individual to team-based production. The complexity of most projects demands diverse forms of expertise acquired over time through experience. To realize a project, it is therefore necessary that the needed knowledge be provided by many specialists, whose efforts are integrated through a collaborative process. It is also hoped that bringing together expert knowledge from diverse domains may result in synergetic effects whereby the whole becomes something different from the sum of its parts. The integration of the specialists' diversified approaches, methods and strategies ideally enables a multifaceted view of a given problem and therefore enhances the creative potentials of the team members [1,2]. This multifaceted view is possible only if there is a shared understanding of the problem and the various approaches to solving it.

Research on interdisciplinary teams shows that this common ground is often missing, which causes team members to complain of inefficient work [3]. Differing technical languages, different approaches to problem-solving and a lack of familiarity with other members' disciplines often leads to problems in such teams [4]. In addition to communication and coordination, interdisciplinary teams must also develop consensus about the project's goals, have a clear understanding of team members' diverse professional areas of expertise and acquire a meta-knowledge connecting the different areas of needed expertise as they relate to the project that has brought them together. This process is called knowledge-sharing.

To validate this hypothesis, researchers at the Fraunhofer Institute for Industrial Engineering in Stuttgart, Germany, constructed a questionnaire based on interviews with members of interdisciplinary research and development teams [5]. Openness, personal trust and willingness to compromise, common interests and sympathy, spatial proximity and technical communication capabilities were considered positive factors for communication by these team members. Factors influencing coordination consisted of systematic project management, time management and stability of team composition. The categories associated with knowledge-sharing included a shared understanding of objectives and problems, shared terminology, experience with interdisciplinarity and motivation to work in interdisciplinary teams.

Steinheider's previous investigations of research and development teams [6] in corporate organizations and scientific institutions found coordination and knowledge-sharing to be more problematic within teams than communication. As reported in this previous study, there were few complaints that team members lacked competence or were uninterested in interdisciplinary collaboration. Steinheider concluded that cooperation problems are not automatically avoided by the careful formation of a team. Instead, she argues that the process of knowledge-sharing is critical and that strategies and methods to support this process therefore need to be devel-

Fig. 1. *Pockets Full of Memories* installation layout, 2001. (Photo © George Legrady)

Brigitte Steinheider (psychologist), Department of Psychology, University of Oklahoma, Tulsa Graduate College, 4502 East 41st Street, Tulsa, OK 74135, U.S.A. E-mail: <bsteinheider@ou.edu>.

George Legrady (media artist), Media Arts & Technology Graduate Program, University of California, Santa Barbara, CA, U.S.A. E-mail: <legrady@arts.ucsb.edu>.

Based on a paper presented at ISEA 2002, 11th International Symposium on Electronic Art, Nagoya, Japan, 2–31 October 2002.

Fig. 2. ***Pockets Full of Memories*** **opening night, 2001. (Photo © George Legrady)**

oped. Her studies have also shown that these cooperation problems are associated with longer product development time, increased product development costs and decreased product quality. On the subjective level, team members complained about stress and reported lower job satisfaction compared with team members who reported less difficulty in collaboration. Problems were more frequent in teams with numerous members and/or external partners. Collaboration in teams was enhanced by prior team-based experience, knowledge about product development processes and high commitment among team members.

CASE STUDY: *POCKETS FULL OF MEMORIES*

The aim of the following case study was to apply the collaboration model to an international and interdisciplinary team creating a digital media art project. The analysis addressed the production and associated problems of a digital on-line art installation produced by a multinational team of specialists. The work had its inaugural exhibition from April to September 2001 at the Centre Pompidou Museum of Modern Art in Paris. *Pockets Full of Memories (PFOM)* consists of a visual archive of digitally scanned personal objects contributed by the audience (see Figs 1 and 2).

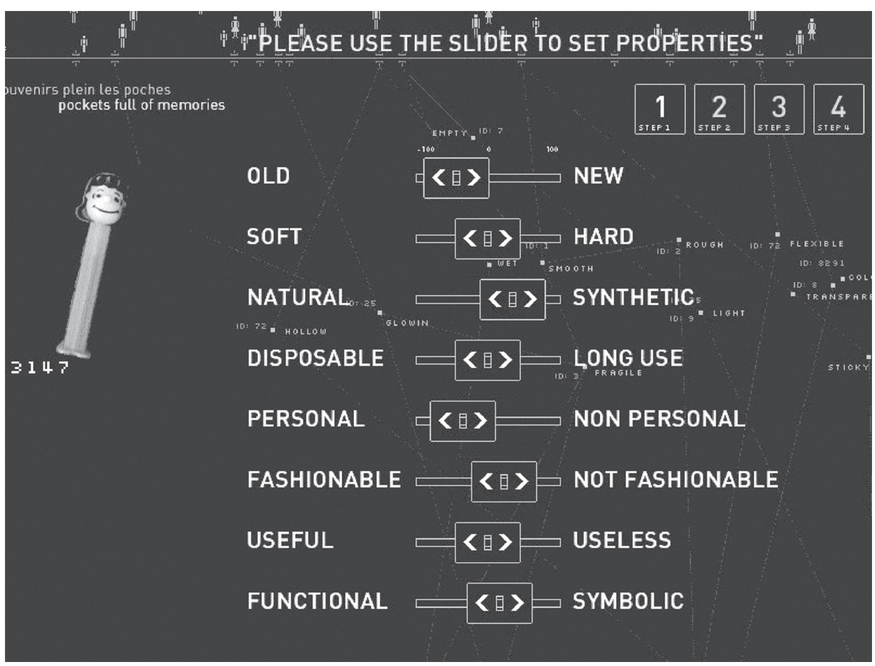
The objects in the archive were organized by a neural-net–based, self-organizing map algorithm according to attributes defined by the contributors in a questionnaire (see Fig. 3). Visitors described their objects with keywords and evaluated them with a semantic differential between two poles, e.g. old/new, useful/useless. The archive was simultaneously projected on a large scale in the museum and posted on the Internet at <www.pocketsfullofmemories.com>. Visitors and Internet users could view the objects and add comments via terminals. The goal of the installation was to actively integrate visitors in the creation of the archive and to enhance interaction between the audience and the data structure.

This project was realized by a spatially dispersed international team in Helsinki, Budapest, Stuttgart, Paris and Santa Barbara, California [7]—specialists with heterogeneous backgrounds in art, graphic design, engineering, cognitive science and computer science. Because of the spatial dispersion of the team, communication was done mainly via e-mail or telephone in English, but also in French (between the artist and the Paris-based team members) and Hungarian (between the artist and the Budapest-based engineering team) as well as in Finnish and German. Due to its innovative nature and its integration of science and art concepts, the complexity of this project was rather high.

DEVELOPMENT PROCESS

Artist George Legrady met Timo Honkela at CIRCUS, an arts-science conference funded by the European Union (EU), in October 1998 and was then introduced by Honkela to self-organizing maps. Honkela had completed his dissertation under the cognitive scientist Teuvo Kohonen on applying Kohonen's self-organizing map (SOM) on semantic data clustering. These SOM algorithms are used to aggregate biostatistical data in order to find sub-groups with similar characteristics. As Legrady was interested in constructing archives, he was looking for complex algorithms with which to

Fig. 3. ***Pockets Full of Memories*** **questionnaire, 1024 × 768 pixels, 2001. (© George Legrady)**



sort his data. He and Honkela met again at the next CIRCUS meeting in Angoulême, France, and brainstormed on different project ideas. At this time, Legrady was contacted by Boris Tissot, an exhibition organizer working for the Centre Pompidou, to discuss an exhibition proposal, and an initial version of the *PFOM* project came into being. Production began in the early summer of 2000, with a spring 2001 deadline.

The *PFOM* project demanded participation of an interdisciplinary team of specialists to resolve specific research solutions such as design for a scanning station, development of a questionnaire, data management, storage optimization, network systems, data visualization, Internet interaction and visual identity.

Legrady contacted the following partners:

- Timo Honkela and his team, responsible for the implementation of the SOM algorithm
- C3, a Hungarian engineering/artist team based in Budapest, with whom he had previously worked, who were to develop the hardware/software for the scanning stations
- The Projekttriangle design team in Stuttgart, who would be responsible for the visual identity and interface design of the installation
- Brigitte Steinheider, a German psychologist, who helped with the construction of a questionnaire for data assessment.

Work began in mid-July at a retreat in the Finnish forest country with Legrady and Honkela's team; here the initial development and testing of the SOM algorithm took place. A kickoff meeting took place a week later in the south of France, attended by the Finnish team, Legrady and Steinheider. The team collected everyday objects such as candies, pens and jewelry, which were scanned and evaluated using the questionnaire; these objects were used to test the SOM. Ten days later, the French curator and the German design team joined the group to further discuss project development. Members of C3 were not able to come to this meeting; another meeting was therefore scheduled in Budapest, in September 2000, with Legrady, the curator, the C3 Budapest engineering team, the Finnish team and the German design team. Timo Koskeniemmi, who was part of the Honkela team and responsible for the SOM software implementation, went to Budapest in October 2000 to collaborate directly with the Hungarian engineering team. The main production work took place in Budapest, where the scanning station was fabricated, image scanning and touchscreen interaction were developed and the questionnaire assembled in accordance with the design developed in Stuttgart. The first prototype was shown and beta-tested 2 months later at the ISEA conference in Paris, 6–11 December 2000. A few weeks later, Legrady concluded his 5-year stay in Germany and moved back to California. The web implementation was realized in March 2001 by Andreas Engberg in the CREATE Research Lab at the University of California, Santa Barbara. The final completed version of the installation was assembled for the first time at the Pompidou inaugural exhibition. The systems integration of the scanning station with the data-handling computers and redesign of the data visualization were realized on site in the museum gallery space days prior to the opening. Two Parisian engineers were contracted at that time to supervise the assembly and assure the proper functioning of the technology for the duration of the exhibition. *Pockets Full of Memories* opened on 18 April 2001 on the main floor of the Centre Pompidou in Paris and was shown without interruption until 4 September 2001. During this period, it received over 20,000 visitors, who contributed over 3,400 objects to the database archive [8].

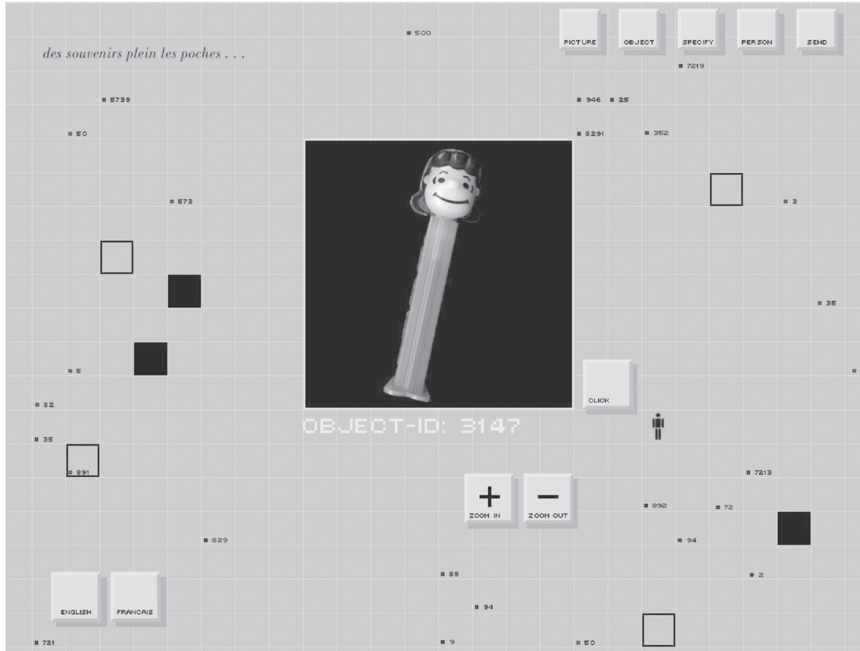


Fig. 4. Prototype of questionnaire screen design, 1024 × 768 pixels, 2001. (© George Legrady)

In the following section, the development of the art installation will be described from Steinheider's perspective as an industrial and organizational psychologist. Her assessment is based on observations at the project kickoff in the south of France and on her discussions with Legrady and with other team members. In addition, team members were mailed questionnaires following the completion of the project in which they were asked to describe their motivation to participate and their experiences. Participants also rated 72 statements assessing communication, coordination and knowledge-sharing within the team. Some participants—for instance, the Parisian engineers—could not be contacted. Seven team members answered the questionnaire: the curator, the Finnish team leader, the Hungarian engineer, all three team members of the German design team and the Swedish engineer in Santa Barbara, California, who set up the web site. Besides Legrady, those listed above were the most involved in the development of the installation, and the following evaluation is based on their answers.

TEAM STRUCTURE

Overall, 14 geographically dispersed persons were involved in the development of the installation, a team size that made direct communication between all members difficult. The team size, scattered locations and diversity of languages and professions all resulted in the development of subteams. This situation was further complicated by membership fluctuations and an unstable group structure. For instance, the leader of the

Finnish team initiated the work process at the kickoff but then assigned his qualified student, Timo Koskeniemmi, to implement the task. Furthermore, web development also shifted to Santa Barbara 4 months prior to the exhibition opening. Finally, the two Parisian engineers were contracted to join the team during the last weeks of the production phase to set up the installation in Paris.

Many of the team members had previously participated in interdisciplinary collaborations and product development processes but stated that this project was far more complex than what they were used to. The curator and the Hungarian engineer had the most experience with team-based collaborations in product development processes. Both enjoyed interdisciplinary teamwork; they stated that it allowed them to learn from other disciplines. A few others reported, however, that one of the disadvantages of such collaborations is that discussions of technical details must remain at a superficial level, which requires additional interaction to further clarify expectations and requirements. All team members who answered the questionnaire were aware of the interdependencies of the specialized contributions and the consequences when one task falls behind schedule.

Team members differed in their motivation to participate: Three were motivated by the opportunity to work on an art project to be exhibited at the internationally prestigious Centre Pompidou; they also wanted to work with an artist and to gain insight into an interdisciplinary work that integrated artistic, scientific and technological components and perspectives. One respondent liked the challenge involved in realizing such a complex project. Travel to the various countries was mentioned as a benefit, as was the challenge of meeting and working with an international and interesting group of people of diverse backgrounds. Reinforcing moments were experienced when progress became obvious through the achievement of milestones. Pleasure was also experienced in seeing the completed installation itself, watching the visitors interact with the questionnaire and seeing their delight when they saw their objects projected on the museum wall. Team members felt rewarded by the result of the project even though the budget allotted them wages below the professional standard. Individual work packages were not clarified at the start, and some of the subteams realized that their workload was heavier than they had initially planned. As a consequence, all participants agreed that project roles and individual responsibilities in such ventures should be more precisely clarified at the start of the project, with precise and binding specifications.

The subteams differed widely in their perception of problems associated with the product development process. The engineering teams pointed out the necessity for technical specifications and detailed work packages, and the design team complained about the lack of centralized project management, whereas the curator and the Finnish scientist concentrated mainly on communication problems that arose due to differences in mentality and language. This diversity in perception was also reflected in the evaluation of communication, coordination and knowledge-sharing processes. Overall, team members had the most complaints about coordination problems, followed by knowledge-sharing, whereas communication problems were perceived as less frequent.

Fig. 5. *Pockets Full of Memories*, DEAF03 opening, 2003. (© George Legrady)

Communication

Communication is enhanced by openness, personal trust and willingness to compromise, common interests and sympathy and spatial proximity. Dispersed teams have more difficulties in developing trust, because communication is reduced to written messages, and thus all forms of nonverbal cues for signaling understanding and sympathy are excluded. The majority of team members pointed out that team meetings would have been more frequent if the geographical distance had not been so great. The curator emphasized that personal communication helps to improve understanding between team members because of the exchange of non-work-related information and nonverbal signs of understanding. He telephoned team members regularly to ascertain by the sound of their voice whether they agreed on something or not.

In addition, the cultural mentalities of and chemistry between team members have to be taken into account. Scandinavian people, for example, are relatively less hierarchically minded, leading to less-differentiated project roles. The Finnish team leader tried to motivate and educate his students by letting them participate in this project without first discussing their inclusion with Legrady. Some conflicts surfaced when the participating Finnish design student realized that a professional design team had already been selected for the project's visual identity design. Because of scheduling conflicts, there was no common project kickoff including all team members. Instead, kickoffs took place individually within each subteam. This delayed the establishment of precise rules and norms of communication and the development of a team spirit, making it difficult to build trust between team members. Even though team members spoke different languages, had diverse cultural backgrounds and differed in age (ranging between 25 and 51 years) and professional expertise (from student to seasoned professional), these differences were not perceived to hinder teamwork. However, team members differed considerably in their perception of teamwork: Competition, resentment and openness were the issues that produced the greatest variance in their responses.

Coordination

Factors influencing coordination included systematic project management, time management, and stability and competence of team composition. The time schedule of *PFOM*'s development was very tight, and there was time pressure from the beginning: teamwork started in July 2000, and the prototype was presented at a conference in December 2000. The tight schedule was cited by one team member as the factor most detrimental to the work process. Meeting the deadlines was further complicated because some team members had previously committed to other projects, not realizing the complexity of the synchronization process needed for integration of the tasks. The final production phase began when Legrady moved back to California 4 months prior to the opening, and some team members felt disconnected by the absence of Legrady during his relocation.

The project development was an evolving process. Legrady did not want to prejudge the individual contributions, as he wanted to learn from the various disciplines and their results. This approach enhanced team members' options for problem-solving and realization of their individual ideas but did not specify what was expected from them and thus created uncertainties and increased subjective stress. At various stages, Legrady responded to results by modifying components. Specifications changed as a consequence, so that significant parts had to be redesigned and re-implemented. Some delays resulted, and specifications were interpreted by some team members as non-mandatory decisions. The design team, for example, was very disappointed when the initial design concept they had worked on for three months had to be set aside.

The engineers were reminded of the necessity for a detailed project plan with detailed technical specifications prior to starting work on a complex project like *PFOM*. They had the sense that the product development process could have been improved by a preliminary technical overview, where the whole project's details would have been mapped out ahead of time. Such a precise plan would have made the engineers' work easier, but would have greatly impeded innovation and experimentation, reducing the degrees of freedom for the artistic design process. Legrady wanted to have multiple options at each step of the way, but team members perceived this approach as a lack of systematic project management.

The evolving production development process caused conflicts for the curator, who was confronted at one end by his director's nervousness about the risks of presenting a highly technological and untested new exhibition for the first time and, on the other, by the unresolved problems he witnessed during technically challenging production phases. The legal situation was unclear, as the project began without binding contracts between team members defining concrete work packages and responsibilities. The curator saw the need to define responsibilities through written agreements and contracts and was the most adamant in requesting these. In the end, contracts were signed between the museum and the two major participants but only after the end of the production.

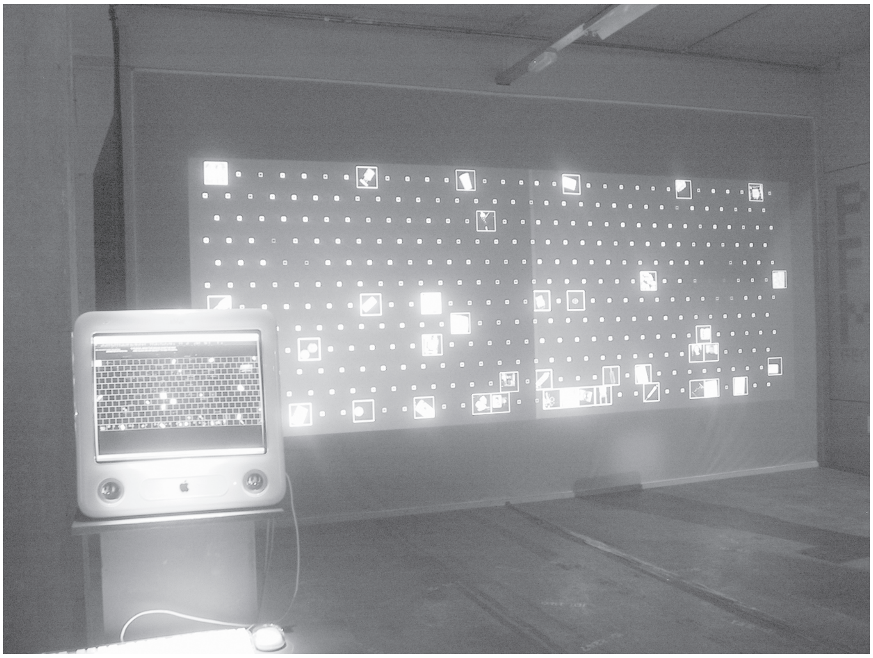


Fig. 6. *Pockets Full of Memories*, DEAF03 objects and their movements, 2048 × 768 pixels, 2003. (© George Legrady)

Subteams nonetheless proceeded with production work as they did not doubt the technical competence and integrity of the other subteams. Subteam members were well aware of the interdependencies between the tasks, but as some of the components took longer to complete than expected, subsequent tasks were delayed as a result. Further problems arose out of team members' divergent objectives. All the disciplines overemphasized their part in relation to others. Team meetings might have resolved the problem, but due to the spatial distance, these were rare. The complexity of the project also made it difficult to prepare team meetings thoroughly. There was hardly any time for documentation of the respective results, as project solutions emerged out of the ongoing production.

Knowledge-Sharing

The categories associated with knowledge-sharing are a shared understanding of objectives and problems, shared terminology, adopting the other's perspective, experience with interdisciplinarity and motivation to work in interdisciplinary teams. Due to the range of different knowledge domains represented, some team members found it difficult to develop a shared understanding of the project at the outset. The Finnish team leader stated that the project should have begun with a workshop attended by all, at which the objectives, tasks, terminologies and timetables of the project would have been defined. This would have enhanced trust and mutual understanding, as the ways of thinking and methodological approaches of the various other disciplines were largely unknown to the subteam members. That members spoke different native languages also resulted in certain misunderstandings. The curator's description of a playful interface design was misinterpreted and led the design team to create a game aesthetic (see Fig. 4). They had interpreted the term literally, developing a very colorful and three-dimensional design for the questionnaire, whereas Legrady and the curator meant it more in an associative way and preferred a more minimal design. The late delivery of the final redesign impeded the Budapest production team, who had to work around the clock to meet the beta-testing deadline.

Team composition stability was affected when new persons were brought into the project. Following the beta testing in December 2000, web interface production shifted from Budapest to Santa

Barbara. For the duration of the Pompidou exhibition, the curator contracted two Parisian engineering students to supervise system maintenance throughout the exhibition. With each new member of the team, a common ground had to be developed anew. Due to proximity factors and close working relationships, the Santa Barbara team was much more integrated into the spirit of the project, whereas the Parisian engineers saw it primarily as a summer job.

EFFORT AND RESULTS

Team members stated in the questionnaire that they were highly motivated to participate in this project and felt entirely competent to fulfill their contributions. Even though they miscalculated project time and costs, they gave the best they could. Asked to evaluate the contributions of other participants, team members perceived them as equally competent, but less motivated compared to themselves. Respondents were not convinced that the other team members gave their best and blamed them for failures in keeping the time schedule, which led to delays of their own work. The positive self-evaluations compared with the less positive evaluation of other team members are an indicator that participants functioned as a group but did not become a solidified virtual team. In hindsight, most of the respondents stated that they would have made significant changes to their contributions, not so much on the conceptual level as in the realization of their part of the installation.

FURTHER DEVELOPMENTS AND OUTLOOK

Pockets Full of Memories was shown at the DEAF 03 Dutch Electronic Art Festival in Rotterdam, the Netherlands, from 25 February to 9 March 2003 (see Color Plate A No. 2 and Fig. 5). During this time, 600 data sets were scanned (see Fig. 6). The installation was redesigned by a team of eight persons who worked simultaneously on site [9]. Legrady had become dubious about dispersed teams as a result of the first production phase. Installing the exhibition a second time required the continued participation of the Hungarian engineer and the German design team. Three new members were brought in for this production, two having previously worked with Legrady and the third being the in-house engineer.

Six months later, *PFOM* was shown at Ars Electronica in Linz, Austria, 9–21 September 2003. During that time, 800 data sets were collected. The production team this time consisted of four persons [10], as the installation had become standardized at DEAF. *PFOM* was exhibited a month later in the Aura Exhibition in Budapest, Hungary (30 October–30 November 2003), organized by C3. With the standardization of the installation, the production team became increasingly smaller. In Budapest, it was realized solely by the Hungarian engineer, Marton Fernezelyi, with the design team working from a distance.

WORKING WITH CREATIVE PEOPLE

Creativity can only occur when a task involves complex and ill-defined problems that require the development of novel and useful solutions. Structuring the problem is a key component of the creative process. It involves defining the problem and gathering information, which allows the formulation of concepts that permit an understanding of the problem. The acquired information enables recombinatory possibilities in new configurations, thus allowing the generation, development and implementation of new ideas.

In an effort to successfully realize a creative installation, all team members involved have to define problems, gather information and then progressively refine and extend initial ideas toward successful implementation. Since all of these activities are difficult, creative work is a demanding and time-consuming process [11]. Furthermore, it is uncertain in its outcome, as multiple solutions are possible, risky because the outcome cannot be predicted or assured in advance, and stressful because of its iterative character. In order to cope with these conditions, creative people have high levels of motivation and identify personally with their work. They also demand an equivalently high commitment from others, making collaboration with them very intense. One questionnaire respondent stated that he would have reconsidered the *PFOM* collaboration if he had known that he would have to sacrifice his personal life throughout the exhibition's production phase.

In contrast to relying on standardized solutions, creative people approach problems in an exploratory mode, examining possibilities, searching for information and developing a conceptual model. Following this exploration, however, creative workers seem to adopt a highly analytical and evaluative position, identifying flaws as a basis for further elaboration and refining of these ideas. As a consequence, their harsh evaluation of their own work or that of others might sometimes seem like an emotional expression, as the design team stated after their initial concept was rejected. Research has shown that close supervision and highly detailed work plans tend to inhibit the performance of creative people [12]. As a consequence, even though it might be desirable, especially in light of tight schedules, to have exact plans, this is not very likely to result in the most innovative and creative solution.

CONCLUSION

This installation exemplifies how creativity and innovation result from the confrontation with and integration of different perspectives, in this case the integration of the SOM algorithm into the context of an art project. Overall, the development process was judged by most team members to be "very intense," but they found it worth their effort. Despite the budgetary and time constraints, an innovative installation was realized and was very well received. Coordination and knowledge-sharing were the most problematic processes. In order to optimize the innovative potentials of interdisciplinary teams and to reduce team member stress, artist team leaders can apply the following lessons from this project:

- Team building should not be done with only individuals' expertise in mind. Instead, individual and cultural differences, as well as geographical distance between team members, must be considered. Because teams with more than 10 members tend to form subteams, smaller teams are preferable. Team member familiarity and spatial and temporal proximity improve collaborations.
- A single kickoff with all team members present helps in developing a mutual understanding of the project. All terminology should be standardized and key concepts of the individual disciplines must be defined. It is also necessary to invest time in clarifying the task and defining individual subtasks. In-person meetings are important to develop trust and should be more frequent at the beginning.
- Regular review of prototypes is critical to assure mutual understanding.
- Knowledge about product development processes helps team members to shift their focus from the subtasks to the overall task. Reminding team members of their part in the overall

process and the interdependencies between the tasks might increase adherence to the time schedule and reduce delays.

- Team members should accept the stress and initial uncertainty of the result as part of the product development process. Team leaders should trust their team members and their expertise, motivate them and try to reduce their stress.

Generating innovative work is a very intense and demanding task—but also very rewarding!

References

1. H.G. Denton, "Multidisciplinary Team-Based Project Work: Planning Factors," *Design Studies* **18** (1997) pp. 155–170.

2. C.D. Schunn et al., "The Growth of Multidisciplinarity in the Cognitive Science Society," *Cognitive Science* **22**, No. 1, 107–130 (1998).

3. W. Janssen and P. Goldsworthy, "Multidisciplinary Research for Natural Resource Management: Conceptual and Practical Implications," *Agricultural Systems* **51** (1996) pp. 259–279.

4. R. Bromme, "Beyond One's Own Perspective: The Psychology of Cognitive Interdisciplinarity," in P. Weingart and N. Stehr, eds., *Practicing Interdisciplinarity* (Toronto: Toronto Univ. Press, 2000) pp. 115–133.

5. B. Steinheider and E. Burger, "Kooperation in interdisziplinären Entwicklungsteams," in *Komplexe Arbeitssysteme—Herausforderung für Analyse und Gestaltung* (Dortmund, Germany: GfA-Press, 2000) pp. 553–556.

6. B. Steinheider, "Supporting the Co-Operation of R&D-Teams in the Product Development Process," *Proceedings of the 5th Conference on Engineering Design and Automation,* 5–8 August 2001, Las Vegas, NV, U.S.A.

7. The team included Timo Honkela (Kohonen self-organizing neural-net algorithm), Helsinki; Marton Fernezelyi (scanning station production, software integration), Center for Culture and Communication (C3), Budapest; Projekttriangle Design, Stuttgart; Boris Tissot, exhibition organizer, Centre Pompidou; and Andreas Engberg, web component, Create Lab, UC Santa Barbara.

8. G. Legrady and T. Honkela, "Pockets Full of Memories: An Interactive Museum Installation," in *Visual Communication* **1**, No. 2, 163—169 (2002).

9. This team consisted of Stephan Drescher (DEAF engineer); Marton Fernezelyi (C3, Budapest); Ethan Kaplan (UCSB); Martin Grothmaak, Juergen Spaeth and Daniela Djokic (Projekttriangle, Stuttgart); Legrady; and Andreas Schlegel, who did the visualization from Santa Barbara.

10. The team members were: Marton Fernezelyi (C3, Budapest), Peter Huetmannsberger from the exhibition space (local Linux expert), Andreas Schlegel and Legrady.

11. M.D. Mumford et al., "Leading Creative People: Orchestrating Expertise and Relationships," *Leadership Quarterly* **13**, No. 6, 705–750 (2002).

12. J.T. Barnowe, "Leadership and Performance Outcomes in Research Organizations," *Organizational Behavior and Human Performance* **14**, (1975) pp. 264–280.

Brigitte Steinheider is Assistant Professor in the Department of Psychology at the University of Oklahoma, Tulsa Graduate College. She received her MBA in 1992 from the University of Düsseldorf and her Ph.D. from the Technical University Dresden, Germany, in 1996. Her research focuses on interdisciplinary collaborations and knowledge-sharing processes in organizations and research institutions.

George Legrady is Professor of Interactive Media at the University of California, Santa Barbara, with a joint appointment in the Media Arts & Technology graduate program and the Department of Art Studio. His interactive installations have been exhibited internationally, most recently at the Kiasma Museum of Contemporary Art, Helsinki, the Centre Georges Pompidou, Ars Electronica, DEAF03 and the San Francisco Museum of Modern Art. He has received awards from Creative Capital Foundation, the Daniel Langlois Foundation for the Arts, Science, and Technology, the Canada Council and the National Endowment for the Arts.