The Conceptual Organization:
An Emergent Collaborative R&D Organizational Form

Diane H. Sonnenwald
University of North Carolina
CB #3360, Chapel Hill, NC
Phone: +1-919-962-8065, Fax: +1-919-962-8071
USA
E-mail: sonnenwald@ils.unc.edu

ABSTRACT

This research suggests a new type of research and development (R&D) organization, called the conceptual organization, is emerging that relies on and facilitates collaboration in research and development. The conceptual organization is based on a long-term vision that addresses large complex and challenging problems of national and global importance. Its purpose is to work towards this vision, quickly and effectively contributing to relevant dynamic knowledge bases and meeting diverse stakeholder needs with minimum capitalization and start-up costs. To achieve this, it has an explicit conceptual organizational structure in addition to a physical structure, both of which are interwoven across other external organizational and physical structures. The conceptual organization engages scientists through the appeal of their vision and socio-technical infrastructures that encourage and facilitate collaboration. Its power is primarily integrative in nature, and collaboration is a primary mechanism used to achieve the organizational goals. These conclusions are based on an in-depth 2-year case study of an R&D organization.

INTRODUCTION

Collaboration is an integral component of many research and development (R&D) endeavors because typically no single individual has the required knowledge and resources needed to address research complex research questions or problems. Organizations strive to discover ways to facilitate collaboration (e.g., Kanter, 1994). For example, it has been shown that organizational culture can impede collaboration because its reward and value structures favor individual contributions (Orlikowski, 1993). In response, some organizations have implemented special practices, e.g., radically collocated project team rooms, to facilitate collaboration (Teasley, Covi, Krishnan, & Olson, 2000). Government and industry have also worked together to form new forms of organizations, such as academic-industry research parks and industry-university research centers, to facilitate collaboration.

This paper proposes that a new type of organization, called the conceptual organization, appears to be emerging that facilitates collaboration in research and development. Data analysis suggests the conceptual organization is based on a long-term vision that addresses large complex and challenging problems of national and global importance. Its purpose is to work towards this vision, quickly and effectively contributing to relevant dynamic knowledge bases and meeting diverse stakeholder needs with minimum capitalization and start-up costs. To achieve this, it has an explicit conceptual organizational structure in addition to a physical structure, both of which are interwoven across other external organizational and multiple physical structures. The conceptual organization is led by paradigm creators and pioneers, and has few employees in the traditional sense. Rather it engages scientists through the appeal of its vision and implementation of socio-technical infrastructures that encourage and facilitate collaboration. Its power is primarily integrative in nature, and collaboration is a primary mechanism used to achieve its organizational goals.

RESEARCH METHODLOGY

The framework for the conceptual organization emerged from an in-depth 2-year case study of a R&D center. The primary purpose of the case study was to investigate how social processes and information and communications technology (IC&T) technology may facilitate and/or impede collaboration in research and development.

Research Setting

The case study took place at a R&D center in the USA. The R&D Center was first funded late 1999, with a five-year $15 million dollar commitment from a national funding agency with matching support from several participating universities, corporations and a non-profit foundation. Initially, the Center had approximately 30 faculty scientists and 82 students and postdoctoral fellows, and three full-time staff members. The faculty and students were located at four universities in the U.S. Membership has changed over the years, and at the time this paper was written there were approximately 45 faculty scientists, 70 students and postdoctoral fellows and three full-time staff members physically located at five U.S. universities.

Data Collection and Analysis

This case study began during the beginning stages of the center and has continued for two years. During the proposal stage initial plans for the center were developed and submitted to a national funding agency for review. Next, the funding agency organized an on-site review at which the proposed center management team and invited university administrators and corporate and private sponsors presented more detailed plans and motivation for the center. Approximately 6 months later, the center was approved and it officially began operating two months later. It had been in operation for two years at the time this paper was written.

While conducting the case study, the author was a participant observer. As noted by Adler and Adler (1987), three levels of participant observation are possible: complete, active and peripheral. The author primarily assumed a complete membership role, switching to a peripheral membership role when activities focused on research outside her area of expertise. As a complete member, the author had functional, in addition to research, roles in the research setting. For example, the author served as the Center Coordinator of Social Science Research Efforts and a member of the Center management team. She actively participated in the management meetings, contributing to discussions and participating in decision-making. However, when the meetings and decision-making focused on research in natural science and engineering topics, topics not in the author's areas of expertise, she assumed the role of a peripheral participant observer. She observed the activity, taking notes and audio-recordings, and occasionally discussed events and outcomes with meeting participants but she did not actively participate in the discussions and decision-making. Seventy-three management team meetings were held during the two-year study, and the author observed and participated in these meeting. The author was a peripheral member participant in center-wide weekly research meetings, generally observing discussions and only completely participating when discussions regarding collaboration and collaboration technology took place. Center members were made aware of the author's roles.

Observation data included transcribed audio-recordings of meetings, video-recordings of videoconferences, meeting and center documentation and researcher notes. These data were analyzed in the ethnographic and grounded theory traditions (Glaser, 1978; Strauss, 1998). Using semantic content analysis (Robson, 2002) patterns and meanings behind the observations were sought. That is, a theoretical framework was not imposed on the data a priori but rather the data were thoroughly analyzed for patterns within the data and the meaning of those patterns. Results were subsequently shared with several center members (informants) and their feedback was incorporated.

Two sociometric surveys were also conducted to provide quantitative data regarding collaboration within the center. The surveys investigated current and future planned or desired collaboration among center members, and took place approximately 12 and 24 months after the center was established. Response rates for the two surveys were 68% and 73%, respectively. The data were analyzed using sociometric techniques (Wasserman & Faust, 1994) to investigate the number of collaborations among scientists and students, collaborations across universities and changes in collaborations over time.

RESULTS

The Conceptual Organization

Data analysis suggests a new type of research and development (R&D) organization, named the conceptual organization, is emerging to tackle large, complex and challenging problems of national and global importance. Its purpose is to discover solutions, quickly and effectively contributing to relevant dynamic knowledge bases and meeting diverse stakeholder needs with minimum capitalization and start-up costs. It has a conceptual organizational structure in addition to a physical structure, both of which are interwoven across other external organizational structures. It has few employees in the traditional sense; most members are scientists who join the organization because they wish to contribute to its vision and goals. The organization provides a management and socio-technical infrastructure that facilitates members working towards its vision and goals. The power of the conceptual organization is primarily integrative in nature, and collaboration is a primary mechanism used to achieve the organization's vision and goals.

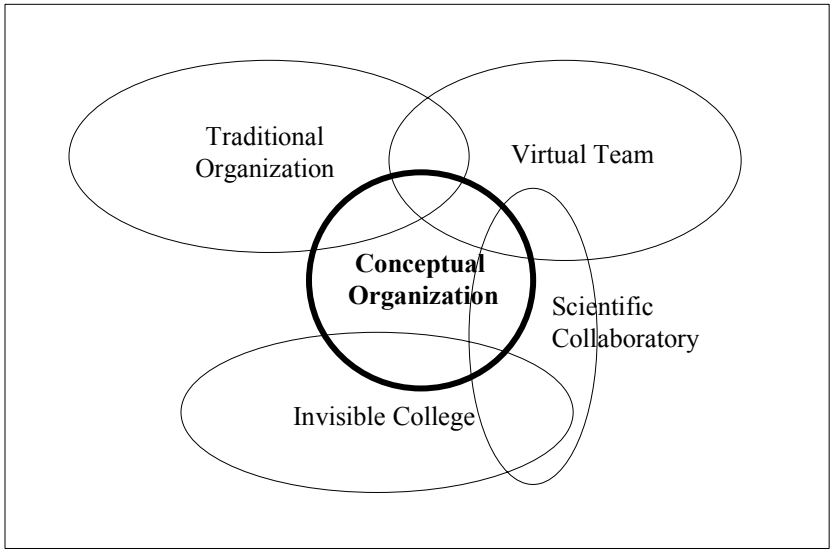

Figure 1. Relationships among the conceptual organization and other types of organizations

Synthesis of Multiple Organizational Forms

The conceptual organization has characteristics, or features, in common with traditional organizations, invisible colleges, scientific collaboratories and virtual teams (Figure 1). For example, similar to traditional R&D organizations, conceptual organizations need physical space. Physical space needs include offices for researchers and staff as well as laboratories to house specialized scientific equipment and conduct scientific experiments. For the conceptual organization, however, these needs are often negotiated and met through relationships with other organizations, such as universities, at which their members are affiliated. Conceptual organizations and traditional R&D organizations also have aspects of management in common, such as a management team that includes directors and an external advisory board who reviews the organization's progress. However, the management structure of a conceptual organization has a more diversified membership as discussed below.

Similar to invisible colleges (Crane, 1972), members elect and are selected to participate in a conceptual organization based on their knowledge and expertise. Physical proximity among members may exist but is not a requirement because members will use multiple methods to communication, including e-mail, electronic file transfer, and groupware systems as well as the telephone and fax. However, the selection and participation process in a conceptual organization is more formal than in an invisible college. Participation in an invisible college is often a matter of knowing and gaining acceptance by its members through interaction with them. In a conceptual organization, there is a formal invitation or application process in addition to the informal process. This is because conceptual organizations provide funding for its members whereas invisible colleges do not (although they may assist in obtaining funding.)

A scientific collaboratory is a network-based facility and organizational entity that spans distance, supports recurring human interaction oriented to a common research area, fosters contact between researchers who are both known and unknown to each other, and provides access to data sources, artifacts and tools required to accomplish research tasks (Science of Collaboratories, 2001). A conceptual organization also shares these characteristics, e.g., a conceptual organization may provide remote (electronic) access to data sources, artifacts, tools and experts. However, the primary goal of a conceptual organization is to address a specific, complex and challenging research issue; the primary goal of a typical collaboratory is to provide remote access to data sources, artifacts, tools and experts to facilitate scientists' individual research initiatives. The nature and emphasis of these goals are slightly different, although the implementation of these goals may have aspects in common. For example, a conceptual organization and collaboratory may use similar technology, such as videoconferencing and web-based applications, to facilitate collaboration across geographic distances. However, a conceptual organization focuses on, and is evaluated with

respect to, the results of its research and educational activities; whereas a collaboratory typically focuses on, and is evaluated with respect to, the utilization of its resources.[1]

Virtual teams are groups of individuals who may not meet face-to-face but work together towards a common goal. Often the team is brought together to address a specific goal and disbanded after that goal is met or when the goal is no longer deemed important (Duarte & Snyder, 1999.) In corporate settings, these teams may cross-organizational boundaries and include individuals from different corporations. A conceptual organization may encourage teams to form to address goals related to the vision, and some of these teams may be virtual. For example, a virtual team could be formed to help coordinate all proposed research efforts going on in two locations on a particular topic. However, a virtual team is more limited in scope and size than a conceptual organization.

Thus, a conceptual organization has characteristics in common with traditional organizations, invisible colleges, collaboratories and virtual teams (see Table 1.) However, it also appears to be a unique organizational form. As described below, its management structure, use of organizational power, types of stakeholders, benefits and challenges combine to represent a new organizational form that relies on, and subsequently, facilitates collaboration.

Table 1. Comparison of Organizational Forms

Characteristic	**Conceptual Organization**	**Traditional R&D Organization**	**Invisible College**	**Scientific Collaboratory**	**Virtual Team**
Management structure	Yes	Yes	No	Only among staff	Usually
Advisory board	Yes	Yes	Informal leadership	Sometimes	No
Membership selection process	Members elect to participate & are selected through formal process	Formal & informal selection processes	Members elect to participate and/or selected through informal processes	Members elect to participate	Often formal
Physical proximity of members	Maybe	Usually	No	Yes for staff; No for participating scientists	No
Economic resources provided to members	Yes, though limited	Yes	Seldom; presentation & consulting fees	No	Yes
Vision	Necessary; Members buy into vision	Yes; members need not buy into vision	No; Accepted paradigms	Not necessary	No
Focused goals	Yes, linked through vision	Yes	No	Yes, for staff; scientists set individual goals	Yes
Power	Integrative, augmented by economic	Economic	Integrative	Economic	Economic
Stakeholders:					
Society	Yes	No	No	Yes	No
Disciplines	Yes	No	Yes	Yes	No
Gov't agencies	Yes	Sometimes	No	Yes	Sometimes
Academia	Yes	Sometimes	Yes	Yes	Sometimes
Corporations	Yes	N/A	Sometimes	Sometimes	Sometimes

[1] Note, the concept of scientific collaboratories is evolving (e.g., see Science of Collaboratories, 2001), and depending on the outcomes on this evolution a conceptual organization may be classified as a specialized type of scientific collaboratory at some point in the future.

Management Structure and Organizational Membership

The management structure of the center observed in this case study has evolved over time. It includes a director who sets the overall prioritization for the center and is responsible for leading the strategic vision and planning process. In addition, the Director for this center takes a lead in organizing the research as well as the dissemination of the research in real time by organizing the center-wide group meetings. As Director, this person also leads the interactions with the external stakeholder groups, such as the national funding agency, an external advisory board, affiliate university administrations and the media. In addition to these responsibilities, the Director teaches and conducts research.

This center also has a Co-Director and a Deputy Director. The Co-Director is a close research collaborator to the Director and is essentially interchangeable with the Director in many functions. The Co-Director's primary responsibility is financial leadership and leadership in strategic planning. The Co-Director is also the leader of the external industrial affiliates group and conducts research. Outside the context of the center, directs a non-profit foundation.

The Deputy Director is a position created explicitly to help with the numerous administration requirements associated with the center. The Deputy Director plays an organizational lead position for the strategic plan and its implementation and accountability. The Deputy Director is also responsible for leading the generation of the annual report and overall compliance with the cooperative agreement between the universities and the funding agency. In a supporting role, the Deputy Director also assists with the numerous outreach programs from the center and represents the center at external venues on numerous occasions.

Thus the directors share in the responsibility of creating and communicating the vision of the center, as well as administrative tasks. This helps to alleviate common burnout, which often leads to a degradation of management's ability to create and maintain a center's vision and vibrant research program.

To further broaden participation in center management, the directors are assisted by a management team that includes a site coordinator for each participating university, a coordinator of collaborative efforts, a higher education outreach coordinator, a kindergarten through 12th grade (K-12) education outreach coordinator, a technical program committee and an office manager. Site coordinators handle location-specific administrative issues, ranging from reserving a videoconference room for weekly meetings to distributing allocated budget funds. The coordinator of collaborative efforts manages socio-technical activities to support collaboration within the center and coordinates social science research done in the center. The higher education and K-12 outreach coordinators oversee the educational outreach activities done by center members and their staff. The technical program committee provides input regarding natural science research and development.

The participation of representatives from each physical location provided ongoing dialog about challenges, progress, perceptions and ways of working at each location. It is a way to interweave the conceptual organization among multiple physical locations and the external organizations at those locations. It eliminates the need for individual scientists to take sole responsibility of coordination and cooperation between their local and remote organizations (in this case, between their local university and the center.) It also facilitates learning about different ways of working and collaborative problem solving when members from different locations suggest how practices at their location may solve problems at other locations. For example, one team member suggested a possible solution to a colleague at a different location:

> *Another thing you can do… to magnify your undergraduate help is that you can have undergraduates getting paid for a certain amount of their research but then getting credit for a certain amount, so that you only have to pay for part of it…We pay[our undergraduate students], but… we also want them to take two semesters of [research credits].*

Similarly, the participation of K-12 outreach, social science, minority and technical program coordinators on the management facilitated coordination and collaboration among these diverse domains.

Scientists and students in the center have a primary affiliation with a university at which they are physically located. They became members by proposing research projects and activities that would help the center achieve its vision, mission and goals. Faculty scientists (current and potential members) submitted proposals that outline research projects that, ideally, support the center's vision and mission. The proposals were reviewed and discussed by members of the center's management team. Criteria used to evaluate the proposals were originally informal and

subsequently became more formal. Primary criteria included: fit to strategic plan, potential impact and scientific merit. Secondary criteria included: collaboration plan, K-12 outreach record and plan, and outside funds attracted

Power within the Conceptual Organization

Boulding (1990) describes three types of organizational power: destructive, economic and integrative. Destructive power, the power to destroy things, can be used as a prelude to production, where things are destroyed or altered to make way for production, and for carrying out a threat. An example of destructive organizational power is the firing of employees who are seen as resisting change in an organization. Economic power is used in all organizations. It involves the creation and acquisition of economic goods, including intellectual property, through production, exchange, taxation or theft. Integrative power involves the capacity to build organizations, inspire loyalty, to bind people together and to develop legitimacy. It has a productive and destructive aspect. In a negative sense it can create enemies and alienate people. All organizations have some integrative power or they could not survive. Some, however, rely on integrative power more than others; these include religious organizations, political movements, volunteer organizations and clubs. Their existence and growth are influenced by the extent to which the objectives of these organizations match the dynamic value structures within a larger population.

The conceptual organization appears to use a combination of integrative, economic and destructive power, however, their primary source of power appears to be integrative. They solicit funding and participation based on their vision, mission and goals. They attract funding from corporations, government agencies and other institutions by convincing them that their vision, mission and goals are valid and achievable. They can not promise an economic return on investment although they offer some hope to funding corporations that they will effectively educate students who may become future employees and generate patents and other knowledge that may have economic value. Conceptual organizations attract scientists and students similarly, i.e., they attract scientists and students by convincing them that the organization's vision, mission and goals are exciting and can provide great personal satisfaction.

The center in this case study used integrative power in developing their vision, mission and goals. For example, when describing the process of developing a vision, the executive director commented:

> *It's intended to be an inclusive process. We've included most of the [faculty] here in the center in this process. Certainly our external advisory board had a part to play. It's iterative… We made our first draft of the vision, mission and goals, and reviewed those with [the faculty]… We then reviewed those with [industrial partners] and with our external advisory board. We got their input, what they thought we should be doing in a strategic direction…we integrated these comments.*

The center augmented integrative power with economic power in that they provide some funding to scientists and students. For example, in the center scientists typically receive one month's summer salary, funding for one graduate student or 50% funding for a postdoctoral fellow, up to $4,000.00 for supplies, and $500 for travel.[2] However, these amounts are by themselves not necessarily sufficient to attract and retain high-caliber scientists who often receive government and corporate funding in much larger amounts. We propose that a vision that scientists believe in is also required.

As in any organization, destructive power is used when members do not meet expectations or keep commitments. This was manifest in the center through decisions not to continue funding several scientists whose work was judged not in alignment with the center's vision, mission and goals. For example, during a meeting deciding funding, participants supported and criticized proposals using comments such as:

> *This [proposed project] was not the lowest on my list, but I really miss the connection to objectives, goals, mission, etc. here. I could not see where this is going to lead.*

These decisions, however, were reached through integrative power. The review was done collaboratively with the technical program committee, consisting of a lead scientist from each location and the center's director, co-director and deputy director. This group also developed the call for proposals. The call included the center's vision, mission, goals and critical needs as well as the proposal process and evaluation criteria. The process included a preliminary proposal in which faculty were requested to provide a title and a brief statement of research objectives (six to eight

[2] During the initial start-up year, funding for purchases of specialized scientific equipment was also provided on an as-needed basis.

lines in length.) The committee provided feedback to the faculty on their preliminary proposals. The preliminary proposals were:

> *A mechanism for earlier dialogue…The benefits are…to attempt to avoid excess overlap [between projects]; …to identify opportunities for collaboration…not only within a given university, but also between universities;…to identify any unmet needs*.

Thus, through interaction with faculty and collaboration among management team members, integrative and destructive powers were used.

Stakeholders of the Conceptual Organization

All organizations, including conceptual organizations, have stakeholders. Stakeholders are those individuals or organizations who have a stake in a given organization's success. Our analysis suggests that stakeholders in a conceptual organization include society, scientific disciplines or paradigms, government funding agencies, businesses and academic institutions.

It appears that society is a primary stakeholder of a conceptual organization's vision in that society legitimizes the government, corporations and institutions that ultimately fund the conceptual organization. For example, the vision of the Center supports green chemistry. Green chemistry in general is currently valued by the American society. The need to develop new processes and products that do not pollute the environment are very much recognized as important throughout the American society. Even with this general support, results and justification of the government's investment is needed. For example, the Center directors have made presentations to the US Congress and met with Senators and Representatives. These activities are necessary in part because if a democratic society does not approve of a conceptual organization's goal, it may organize to limit its funding. Individual politicians may lobby against funding a conceptual organization and/or organizations and individuals may protest its existence. For example, the American society and government appears to be, as a whole, against cloning humans; groups have demonstrated and persuaded the US Congress to forbid human cloning research. It is doubtful the US government would fund a conceptual organization to conduct human cloning research.

Scientific disciplines appear to be stakeholders interested in the mission of a conceptual organization. Disciplines typically wish to see knowledge created and students trained in certain scientific areas. This is motivated by collectively held belief systems and yearning for self-preservation and perpetuation of a discipline or scientific paradigm (Kuhn, 1970), and the mission of a conceptual organization has the potential to contribute to the growth of knowledge in particular scientific disciplines and/or paradigms. For example, the disciplines of chemistry and chemical engineering are stakeholders in the Center; these disciplines want to see research done and students trained in these fields. How this mission is achieved through goals, or objectives, may be of some interest to members of a discipline but this level of detail is typically not of interest to a discipline as a whole.

Government funding agencies, businesses and academic institutions are stakeholders who are typically interested in a conceptual organization's vision, mission and goals. For these stakeholders the vision and mission is necessary but not necessarily sufficient. They are also interested in how the vision and mission will be achieved and measured, i.e., the organization's goals. They are typically concerned about justifying their investment in the conceptual organization to their stakeholders, e.g., federal and state governments, and upper management. For example, the center produced a 226-page report detailing its activities and accomplishments during the preceding 12 months to help justify its government funding. Quantitative measures reported included publications, presentations, patents, supplemental funding, students supported, students graduated, K-12 and minority students reached through outreach activities, and K-12 teachers reached.

Businesses do not appear to seek a return on investment from a conceptual organization in the same way when investing in a company because they anticipate other benefits. For example in a survey of 249 corporations who participated in industrial-university research centers, Gray, Lindblad and Rudolph (2001) found that professional networking, including enhanced student recruitment and improved cooperation with scientists, was the primary factor influencing corporate decisions to maintain their relationship with and support of an industry-academic center. Secondary factors were the perceived relevance of the center's research program and administrative operations. Quality of the research and technical benefits, such as commercialization impact, were not found to impact corporate support of the centers. The center holds bi-annual meetings for its external industrial affiliates group. At these meetings, students' presentations and posters are the major activity; the center directors typically only provide an hour introduction and overview of center accomplishments and goals.

Role of Technology

A conceptual organization must utilize information and communications technology as a mechanism to support its vision and mission, or incur expensive monetary and temporal travel costs. In the center, this has meant using traditional information and communications technology, such as the telephone, fax, mail and e-mail, in ways typical of other R&D organizations and scientific disciplines (e.g., Daft & Lengel, 1984). It has also meant using newer technologies, such as video conferencing and web pages, in innovative ways as mechanisms to support the vision and facilitate collaboration.

Video conferencing is used for center-wide meetings and weekly research meetings. Center-wide meetings are held relatively infrequently (e.g., once every 6-8 months); these meetings included all members at all universities and have been used to share information among all center members. For example, a center-wide meeting was held that introduced the center's mission, management structure and center-wide activities several months after the center was established. A more recent center-wide meeting introduced the center's newly revised vision, mission and objectives. Research meetings are held weekly; all center members are invited to attend these meetings, however, students are required to attend. Each meeting typically lasts 1.5 to 2 hours, and includes 20 to 30 center members. During this time, students and postdoctoral fellows present and discuss their work.

The format and technology used in these meetings have evolved over time. New social protocols to compensate for constraints imposed by the technology, and operations protocols to help reduce technical problems were developed and implemented working with center members and technical staff (Sonnenwald, et al, 2002.) Today these meetings increase members' awareness of one another's work and share progress towards the vision. For example, a member reported:

> *I always learn something…[I] listen to things that seem separate from what am I interested in and I will pick up something I didn't know.*

One drawback to these meetings was their formal nature. Students commented that the introduction of video conferencing, a large audience and PowerPoint™ slides meant they needed to spend more time to prepare their presentations. They felt their presentations had to be as formal as if they were presenting at a conference. Several things have contributed to reducing the formality and increase the interactive nature of these meetings. First, faculty encouraged students to view their presentations as learning opportunities. Second, the directors and key students introduced informal aspects into their presentations, e.g., they used the drawing features of the electronic board to modify their slides in real time. Third, a new practice of having non-work communication before a presentation was initiated. In particular, the facilitator of each meeting asks each presenter several questions about their favorite activities and how they came to be at the center. Interpersonal communication has also been shown to increase trust among distributed team members (Rocco, Finholt, Hofer, & Herbsleb, 2002) and facilitate collaboration (Sonnenwald, 1996).

Project meetings are held on an as needed basis among scientists and students who are collaborating on a project. These meetings were typically held face-to-face and/or via audio-conferencing. Technology is currently being installed to provide video-conferencing and shared electronic whiteboards for small group project meetings.

Face-to-face interaction is traditionally recommended to augment interaction mediated by technology (e.g., Olson & Olson, 2001; Rocco, et al, 2002), and center members meet face-to-face at conferences held by professional organizations. They also occasionally visit members working at other locations, however, such travel is primarily limited to those working in the same state.

A website was created to share center news, expectations and resources among center members and to communicate information about the center to stakeholders. The deputy director manages the content of the website. The content has evolved over time and currently includes: the center's vision statement, contact information, annual reports, call for proposals, virtual tours of lab facilities, center meeting schedules, directory of center members, personal web pages of center members, a news bulletin that contains copies of press releases and announcements of awards and other recognition received by members, and forms to be used by members such as a confidentiality agreement. This type of content can help form a shared identity across distances (Rocco, et al, 2002) as well as help to share results with stakeholders.

The website also contains pointers to resources that provide work, career and personal assistance to members, such as information about lab safety, suppliers, conferences, job interview process and apartment hunting services. This

type of information supports an anonymous mentoring function, allowing center members (as well as the general public) to anonymously find information to assist in their careers and personal life.

Information about opportunities for others to participate in center activities or activities sponsored by the center are included on the website. This includes student and postdoctoral fellowships, upcoming talks, and K-12 and minority outreach activities that teachers and students can participate in. The website also includes a FAQ, or frequently asked questions, about science related to their work. This type of information helps to engage others in the center and establish goodwill with the general public. For example, early in its inception the center received several inquiries challenging its scientific focus by individuals who thought the center would be conducting research that might lead to an increase in environmental pollution. The FAQ was developed to help address such concerns.

Collaboration in the Conceptual Organization

Our data suggest collaboration is an integral mechanism in a conceptual organization. Because the organization's vision and goals focus on complex and challenging problems, the organization will not meet its vision and goals without collaboration among its members. In this context, collaboration includes coordination but goes beyond coordination to include creating a shared understanding, mentoring and shared creation of new knowledge. The center management team discussed collaboration and actions to facilitate collaboration. The following excerpt from a meeting discussing research proposals submitted by members illustrates the importance the center places on collaboration.

> *Person #1: One of the critical areas for the center as a whole is study related to [topic]…there is a lot of opportunity that's being missed between [the three faculty investigating this topic.]…it's not a funding issue, it's really a matter of getting better coordination among at least three investigators and making sure that we've got the right communication and mentoring, etc., going on.*
>
> *Person #2: I really like the idea of every couple of months having a group meeting on this topic…*
>
> *Person #3: We could mandate and allocate these group meetings early on in the funding cycle…to coordinate goals at that meeting…and come up with a written game plan…*
>
> *Person #4: I agree we don't want to go back and tell them that they have to write another proposal and we'll decide when we see that proposal whether they'll get funded or not…*
>
> *Person #1: One proposal would be that we ask the three of them to lead the meeting and open it up to other to go, to contribute. I think there are a few other people I'd like to have there. We could have [A] be the one to write the summary. And you know darn well, if [B's] in the room and it's got to be a collective document, [B] will contribute and it will be good…*
>
> *Person #3: I agree … that that's a great idea. But it needs to go further…Make them produce a document tomorrow and then they go their separate ways. What they need to do is meet regularly as a group and listen to each other….*
>
> *Person #1: let me capture this…mandate a coordination meeting up-front, early in the funding cycle…so there's a [meeting] product which is a research game plan; ask them for dates of subsequent coordination meetings…and we could then state that this area is missing critical force with good opportunities, and encourage them to encourage their students and post-docs to be more collaborative.*

To further investigate collaboration within the center, two sociometric surveys were conducted. As mentioned earlier each survey asked center members to identify other center members they were currently collaborating with. The first survey took place one year after the center was established; the second took place two years after the center was established. The number of collaborations reported among faculty scientists increased from an average of 2.37 per scientist to 3.36 per scientist; a 41.7% increase (see Table 1.) A larger increase was seen in the growth of collaborations among scientists at different universities than among scientists at the same university (61.1% versus 27.6%). This indicates that collaboration among scientists within the organization has indeed developed across universities (and distances). It suggests that the vision, organizational structure and practices within the conceptual organization have indeed facilitated collaboration.

Collaboration reported among scientists and students has also increased (14.6%), although there was a greater increase reported among students and scientists at the same university than at different universities (57.9% versus 9.7%). Collaboration reported among students decreased from year one to year two (19.6%). This was a 42.9% decrease reported among students at the same university, and a 12.3% decrease reported among students at different

universities. These differences may be in part due to student turnover and could also indicate a need to more actively facilitate collaboration among students. Additional research is needed to investigate this issue.

Table 1. Reported Collaborations in the Center

	After 1 year		After 2 years		Change between 1st and 2nd year		
	Total Collaborations	Collaborations per Person	Total Collaborations	Collaborations per Person	Total Collaborations	Collaborations per Person	% change per person
Among all scientists	71	2.37	148	3.36	+77	+0.99	+41.7
Among scientists at the same university	37	1.23	69	1.57	+32	+0.34	+27.6
Among scientists at different universities	34	1.13	80	1.82	+44	+0.69	+61.1
Among all scientists & students	191	1.71	223	1.96	+32	+0.25	+14.6
Among scientists & students at the same university	42	0.38	68	0.60	+26	+0.22	+57.9
Among scientists & students at different universities	139	1.24	155	1.36	+16	+0.12	+9.7
Among all students	193	2.35	128	1.89	-65	-0.46	-19.6
Among all students at the same university	46	0.56	23	0.32	-23	-0.24	-42.9
Among all students at different universities	147	1.79	105	1.57	-42	-0.22	-12.3

It is not known what the optimal number of collaborations is for an organization. Future research includes examining relationships between collaboration data and research productivity measures such as co-authored publications, patents and grant proposals.

DISCUSSION and CONCLUSION

Benefits of a Conceptual Organization

A benefit of a conceptual organization is its ability to contribute to and respond to dynamic needs for new knowledge. This can be achieved through multiple mechanisms. One such mechanism used is the dynamic incorporation of scientific experts in emerging relevant areas. For example, the center has a call for proposals on a two-year cycle. This enables the incorporation of new scientists and research topics every other year. Another mechanism that supports the dynamic incorporation of scientific experts and emerging relevant areas is “seed funding” which is available on a yearly basis. In the center, members and potential members may apply for these funds to support research that shows promise but is at an early stage where it is difficult to determine whether the research effort will be successful or applicable to the vision and mission of the conceptual organization. In other R&D organizations, such efforts have been called “skunk works” but are limited to existing organizational members and are hidden from other parts of the organization. In conceptual organizations, such efforts can be proposed by existing or potential members. These efforts are also legitimized, not hidden from view, and function, or participate, in the organization similar to other research efforts. Thus the results, both successes and failures, are shared among center members so everyone can learn from them. A third mechanism is matching funding. On a case-by-case basis, scientists may also use their funding from the center as matching funds in other grant proposals that may include additional scientists and students as well as emerging relevant research topics. This brings additional resources to bear in addressing the vision, mission and goals of the conceptual organization. A fourth mechanism includes information dissemination and knowledge building among members. As the conceptual organization is

geographically dispersed, information dissemination and knowledge building and creation are augmented through socio-technical methods. In the center, weekly videoconferences are held in which students present their recent work. Students are required to attend and scientists are strongly encouraged to attend. New social interaction protocols and practices as well as state of the art videoconference technology were adopted by the center to support this type of information exchange (Sonnenwald et al, 2002.) Other socio-technical methods used include dynamic web pages and period groups meetings in which all members interested in a particular topic or project meet via audio or video conferencing.

An additional benefit provided by the conceptual organizations appears to be lower capitalization or start-up costs. These lower costs are achieved through the re-use of existing physical spaces and equipment at the associated universities and organizations, limited term and partial commitment to members and the inclusion of students and postdoctoral fellows. The center relies on space and equipment at its associated universities to support the research being conducted by its members, scientists and students. In return, the center has purchased new equipment that scientists and students at the universities but not associated with the center can also access, and of course, it provides funding to enable students to attend the universities and learning opportunities to enhance their education. The limited (two or one year) and partial commitment to scientists (only one month summer salary is typically provided to scientists) further reduces the start-up costs of the center. Of course, the inclusion of students and postdoctoral fellows who are by definition limited-term also reduces or limits start up costs for the conceptual organization.

A further benefit of a conceptual organization may be found in its ability to meet diverse stakeholders' and members' needs. As discussed previously, a conceptual organization's stakeholders can include society, scientific disciplines or paradigms, government funding agencies, corporations and academic institutions. This diverse and important set is an outgrowth of a variety of political, social and economic forces; no other type of R&D entity has a similar broad set of stakeholders. Furthermore, the infrastructure at academic institutions is typically based on department and disciplinary boundaries with fierce competition for resources, authority and territory (Benowitz, 1995; Salter & Hearn, 1996). This is often a barrier when addressing large complex and challenging problems of national and global importance where the best scientists irrespective of discipline, department or institution affiliation are required.

Future Research

Additional longitudinal data is being collected to increase our understanding of this emergent R&D organization. Data from the center discussed in this paper should be augmented with data from R&D centers. Issues to investigate include the longer term impact of this type of organization on collaboration and scientific outcomes, additional effective practices within a conceptual organization, and the longevity of such organizations, e.g., should conceptual organizations cease to exist after their vision and mission are achieved, or should they periodically re-invent themselves identifying new visions and missions. Furthermore, can a conceptual organization exist in for-profit settings? What are the negatives of this new type of organization?

In conclusion, the conceptual organization appears to be an emerging R&D organizational form that utilizes collaboration as a mechanism to achieve its long-term vision and mission. It appears to be an evolutionary approach to facilitate progress towards complex visions that, by their very nature, require interdisciplinary collaboration to achieve. It cannot achieve success without collaboration, and hence implements innovative organizational practices to facilitate collaboration.

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