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Vision as management aid

The conceptual organization: an emergent organizational form for collaborative R&D

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Analysis of organizational documentation, sociometric survey and observation data from a two-year field study of an research and development (R&D) organization suggests that a new type of R&D organization — the conceptual organization — is emerging. It relies on and facilitates collaboration in R&D; it 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 as well as a physical structure, both of which are interwoven across other external organizational and physical structures. Challenges for conceptual organizations may arise as a result of conflicts with traditional norms and practices embedded in university and R&D settings.

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COLLABORATION IS AN INTEGRAL component of many research and development (R&D) endeavors because typically no single individual has the knowledge and resources needed to address complex research questions or problems. Organizations strive to discover ways to facilitate collaboration (Kanter, 1994). For example, it has been shown that organizational culture can impede collaboration especially when its reward and value structures favor individual contributions (Orlikowski, 1993).

In response, some organizations have implemented special practices, such as radically collocated project team rooms, to facilitate collaboration (Teasley *et al*, 2000). Government and industry have also worked together to establish new forms of organization, such as academic–industry research parks and industry–university research centers.

This paper proposes that a new type of organization, the conceptual organization, is emerging. The conceptual organization is founded 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.

These ideas emerged from a two-year case study of a research organization. Analysis of organizational documentation, sociometric survey and observation data (including observer notes and audio transcripts) from the case study was sought in order to illuminate the management structure, membership selection, power, stakeholders, role of technology, and collaboration that emerged in this organization.

This paper first proposes a theoretical framework

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for the conceptual organization. Next, the research methodology used in the case study is described, and the results, which include a narrative description of the organizational structure and practices that emerged in a conceptual organization, are presented. The paper concludes with a discussion of potential benefits and challenges in a conceptual organization, and need for additional research.

Theoretical framework

Definition of a conceptual organization

A new type of research and development (R&D) organization, named the conceptual organization, appears to be 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.

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, including offices for researchers and staff, and laboratories to house specialized scientific equipment and conduct scientific experiments.

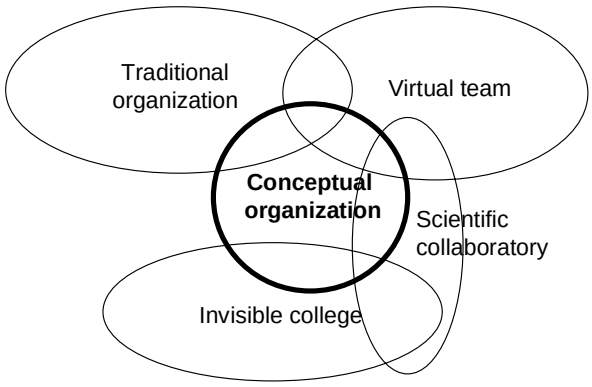

Figure 1. Relationships among the conceptual organizations and other types of organization

These needs are often negotiated and met through relationships with other organizations, such as universities, with 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, which reviews the organization's progress. However, as discussed below, the management structure of a conceptual organization has a more diversified membership.

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 of communication, including e-mail, electronic file transfer, and groupware systems as well as the telephone and fax. However, participation in an invisible college is often a matter of knowing its members and thereby gaining entry and acceptance 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 their 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 among researchers who may be known or unknown to each other, and provides access to data sources, artifacts and tools required to accomplish research tasks (Science of Collaboratories, 2002). A conceptual organization shares these characteristics, for instance, it 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, while the primary goal of a typical collaboratory is to provide remote access to data sources, artifacts, tools and experts to facilitate scientists' individual research or a scientific community's initiatives.

The nature and emphasis of these goals are slightly different, although their implementation may have aspects in common. For example, they may use similar technology, such as video-conferencing 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 it is no longer deemed important (Duarte and 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 co-ordinate 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 stakeholder, benefits and challenges combine to represent a new organizational form that relies on, and subsequently facilitates, collaboration.

A conceptual organization has characteristics in common with traditional collaborative set-ups, but its management structure, use of organizational power, types of stakeholder, benefits and challenges combine to represent a new organizational form

Research methodology

The results reported in this paper are based on an in-depth two-year case study of a R&D center in the USA. The primary purpose of the study was to investigate how social processes and information and communications technology (IC&T) may facilitate and/or impede collaboration in R&D.

Research setting

The center was first funded in late 1999, with a five-year US$15 million dollar commitment from a

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 and are selected through formal process	Formal and 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 and 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	Sometimes	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

national funding agency with matching support from several participating universities, corporations and a non-profit foundation. Initially, the center had approximately 30 faculty scientists, 82 students and postdoctoral fellows, and three full-time staff members. The faculty and students were located at four universities in the USA. 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 US universities.

Data collection and analysis

This case study began during the beginning stages of the center and continued for two years. During the proposal stage, initial plans 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 six 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, she 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 discussing 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 study, and the author observed and participated in them. The author was a peripheral 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 video-conferences, meeting and center documentation and researcher notes. These 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 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 and Faust, 1994) to investigate the number of collaborations among scientists and students and across universities, and changes in collaborations over time.

Case study

The organizational practices of the center are presented in this section to provide a detailed portrayal of a conceptual organization.

Management structure, organizational membership

The management structure of the center 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. The Director takes a lead in organizing the research and its dissemination in 'real time' by organizing the center-wide group meetings. 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, the Director teaches and conducts research.

The center has a Co-Director and a Deputy Director. The Co-Director is a close research collaborator with the Director and is essentially interchangeable with the Director in many functions. The Co-Director's primary responsibility is leadership in finance and strategic planning. The Co-Director is the leader of the external industrial affiliates group and conducts research.

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 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 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 broaden participation in center management further, 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 video-conference room for weekly meetings to distributing allocated budget funds. The coordinator of collaborative efforts manages sociotechnical 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 R&D.

The participation of representatives from each physical location provides 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 another. 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 team facilitate coordination and collaboration among these diverse domains.

Scientists and students in the center have a primary affiliation with the 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 in evaluation 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 (1989) 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 in an organization is the firing of employees who are seen as resisting change.

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.

Conceptual organizations appear to use a combination of the three, but their primary source of power seems to be integrative. They solicit funding and participation based on their vision, mission and

Of the three types of organizational power — destructive; economic; and integrative — conceptual organizations appear to use a combination of the three, but their primary source of power seems to be integrative

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 cannot 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, that is, by convincing them that the organization's vision, mission and goals are exciting and can provide great personal satisfaction.

The center studied used integrative power in developing its 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 it provided some funding to scientists and students. For example, scientists typically received one month's summer salary, funding for one graduate student or 50% funding for a postdoctoral fellow, up to US$4,000 for supplies, and US$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 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, which included the 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 lines). The committee provided feedback to the faculty on their preliminary proposals, which 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

All organizations, including conceptual organizations, have stakeholders. These are those individuals or organizations that 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 studied supported green chemistry, which, in general, is currently valued by the American society. The need to develop new processes and products that do not pollute the environment is recognized as very important.

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 restrict human cloning research. It is doubtful the US government would fund a conceptual organization to conduct such 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.

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 are necessary but not necessarily sufficient. They are also interested in how the vision and mission will be achieved and measured, that is, the organization's goals. They are typically concerned about justifying their investment in the conceptual organization to their stakeholders, such as 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 as they do when investing in a company because they anticipate other benefits. For example, in a survey of 249 corporations that participated in industrial–university research centers, Grey *et al* (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 studied held bi-annual meetings for its external industrial affiliates group, at which students' presentations and posters were the major activity; the center directors typically only provided 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 studied, this 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 (for instance, Daft and 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 was used for center-wide meetings and weekly research meetings. The former were held relatively infrequently (about once every 6–8 months); they included all members at all universities and were 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 one introduced the center's newly revised vision, mission and objectives.

Research meetings were held weekly; all center members were invited, but students were required to attend. Each meeting typically lasted 1.5 to 2 hours, and included 20 to 30 center members. During this time, students and postdoctoral fellows presented and discussed their work.

The format and technology used in these meetings 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). Subsequently, these meetings increased members' awareness of one another's work and allowed them to share progress towards the vision. For example, a member reported:

> "I always learn something. … [I] listen to things that seem separate from what I am 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 larger audience and PowerPoint™ slides meant they needed to spend more time preparing their presentations, which they felt had to be as formal as if they were at a conference. Several things contributed to reducing the formality and increasing 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, for example, 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 asked 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 *et al*, 2000) and facilitate collaboration (Sonnenwald, 1996).

Project meetings were held among scientists and students who were collaborating on a project on an

'as needed' basis. These meetings were typically held face-to-face and/or via audio-conferencing. At the time this paper was written, technology was 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 (for instance, Olson and Olson, 2000; Rocco *et al*, 2000), and center members met face-to-face at conferences held by professional organizations. They also occasionally visited members working at other locations, however, such travel was primarily limited to those working in the same state.

A website was created to share news, expectations and resources among center members and to communicate information about the center to stakeholders. The Deputy Director managed the content of the website, which 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 to form a shared identity across distances (Rocco *et al*, 2000) and to help share results with stakeholders.

The website also contained pointers to resources that provide work, career and personal assistance to members, such as information about lab safety, suppliers, conferences, the job interview process and apartment hunting services. This type of information supports an anonymous mentoring function, allowing center members (and the general public) to find information anonymously 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 included student and postdoctoral fellowships, upcoming talks, and K–12 and minority outreach activities that teachers and students can participate in. The website also included FAQ, or frequently asked questions, about science related to the center's 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 it would be conducting research that might lead to an increase in environmental pollution. The FAQ was developed to help address such concerns.

Collaboration

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

Our data suggest that collaboration is an integral mechanism in a conceptual organization: because the organization's vision and goals focus on complex and challenging problems, they will not be met without collaboration among the members

> 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 others 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 investigate collaboration within the center further, 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 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 2.) 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 developed across universities (and distances). It suggests that the vision, organizational structure and practices within the conceptual organization did indeed facilitate 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 because of student turnover and could also indicate a need to facilitate collaboration more actively among students. Additional research is needed to investigate this issue.

It is not known what the optimal number of collaborations is for an organization. Future research

Table 2. Reported collaborations in the center

Type of collaboration	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 and students	191	1.71	223	1.96	+32	+0.25	+14.6
Among scientists and students at the same university	42	0.38	68	0.60	+26	+0.22	+57.9
Among scientists and 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

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 is the dynamic incorporation of scientific experts in emerging relevant areas. For example, the center investigated in this study had a call for proposals on a two-year cycle. This enabled the incorporation of new scientists and research topics every other year.

Another mechanism is 'seed funding', which is available on a yearly basis. In the center, members and potential members could apply for these funds to support research that showed promise but was at an early stage where it was difficult to determine whether it would 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 hidden from other parts of the organization. In conceptual organizations, such efforts can be proposed by existing or potential members, are not hidden from view, and may fully integrate in the organization through activities such as review meetings. Thus all results are ideally shared among center members so everyone can learn from them.

A third mechanism is matching funding. On a case-by-case basis, scientists could use their funding from the center as matching funds in other grant proposals that could 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.

A fourth mechanism includes information dissemination and knowledge building among members. As the conceptual organization is geographically dispersed, these activities are augmented through socio-technical methods, such as the weekly videoconferences in the center. Other socio-technical methods used included dynamic web pages and period groups meetings in which all members interested in a particular topic or project met via audio or video conferencing.

An additional benefit provided by conceptual organizations appears to be lower capitalization or start-up costs. These are achieved by re-using 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.

For example, the center relied on space and equipment at its associated universities to support the research being conducted by its members, scientists and students. In return, the center purchased new equipment that scientists and students at the universities but not associated with the center could also access, and it provided funding to enable students to attend the universities and provided 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 reduced the start-up costs for the center.

A further benefit of a conceptual organization may be found in its ability to meet diverse stakeholders' and members' needs. The diverse and important set of stakeholders is an outgrowth of a variety of political, social and economic forces; no other type of R&D entity appears to have 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 and 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. 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.

Challenges for a conceptual organization

One challenge for a conceptual organization involves reconciliation with existing academic and disciplinary cultures, within which it is embedded. Members of a conceptual organization must also be active and accepted participants in their university departments and disciplines. Conflict among these can emerge with respect to job performance evaluation and career paths.

For example, one critical job performance evaluation in research universities in the USA occurs when an assistant professor is reviewed for tenure and

The members of a conceptual organization must be active and accepted participants in their university departments and disciplines: conflict among these can emerge with respect to job performance evaluation and career paths

promotion to associate professor. Typically, an assistant professor is required to leave the university where they are employed if tenure is not granted. Decisions regarding tenure are initially decided by colleagues in the same department and discipline (who may not be members of the conceptual organization). Their decisions are based on several evaluation criteria, including: an individual's ability to establish a research agenda or vision; an individual's record of research funding; and recognition of the individual's research contributions in the larger academic community.

All of these may be negatively perceived in cases where an assistant professor is a member of a conceptual organization. For example, an assistant professor's research agenda or vision may be perceived by colleagues as lacking originality or insight because it is linked to the conceptual organization's vision, which would not be credited to the assistant professor. Research funding through a conceptual organization does not have the same requirements or review process as found with national and other funding agencies, and thus may not be as highly valued.

Furthermore, a conceptual organization's vision may require expertise from multiple disciplines. When an assistant professor collaborates with others in different disciplines, it can limit the opportunity for colleagues in her/his discipline to learn about and understand the assistant professor's research contributions. This lack of knowledge or understanding may also contribute to a negative evaluation. Thus, the tenure evaluation process may discourage or even conclude an assistant professors' participation in a conceptual organization, with negative consequences for both the assistant professor and organization.

Associate and full professors must also be active participants in their local university departments and discipline. Activities encouraged by a conceptual organization, such as participation in weekly videoconference meetings providing students at other universities feedback on their research and helping a colleague at another university set up research lab equipment, may not be encouraged or valued by one's local university department and colleagues in the same discipline. Individuals have time constraints and, as a result, a faculty member may find they must make difficult choices between contributing to a local department and their career versus contributing to a conceptual organization.

An additional challenge arises with respect to information flow and competition among researchers. Traditionally, researchers only broadly share information regarding research results. Two or more researchers can simultaneously investigate the same topic without conflict because they have no knowledge about each other's activities. Within a conceptual organization, researchers are sharing information about their ideas and plans broadly. Conflict may arise when a researcher plans work that another perceives as infringing on his/her plans. The overlap may not be intentional, yet finding a resolution may be problematic, involving use of power that would not happen in other contexts. The resolution may have negative consequences for a researcher, and, perhaps, unknown consequences for the research topic in general.

Future research

Additional research is required to increase our understanding of this type of emergent R&D organization. Data from the center discussed in this paper should be augmented with data from other R&D centers. Issues to investigate include: the longer-term impact of this type of organization on scientific outcomes and the culture of, and practices in, science broadly; additional effective practices and challenges within a conceptual organization; and the longevity of such organizations, for instance, 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?

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. It cannot achieve success without collaboration, and hence implements innovative organizational practices to facilitate collaboration.

Notes

1. Note, the concept of scientific collaboratories is evolving (for instance, 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.
2. During the initial start-up year, funding for purchases of specialized scientific equipment was also provided on an as-needed basis.

References

Adler, P, and P Adler (1987), *Membership Roles in Research* (Sage, Newbury Park CA).

Benowitz, S (1995), "Wave of the future: interdisciplinary collaboration", *The Scientist*, 9(13), pages 1–4.

Boulding, K (1989), *The Three Faces of Power* (Sage, Newbury Park CA).

Crane, D (1972), *Invisible Colleges: the Diffusion of Knowledge in Scientific Communities* (University of Chicago Press, Chicago).

Daft, R L, and R H Lengel (1984), "Information richness: a new approach to managerial behavior and organizational design", in L L Cummings and B M Shaw (editors), *Research in Organizational Behavior* (JAI Press, Greenwich CT) pages 191–233.

Duarte, D, and N Snyder (1999), *Mastering Virtual Teams* (Jossey-Bass Publishers, San Francisco).

Glaser, B (1978), *Theoretical Sensitivity: Advances in the Methodology of Grounded Theory* (Sociology Press, Mill Valley CA).

Grey, D, M Lindblad and J Rudolph (2001), "Industry–university research centers: a multivariate analysis of member retention", *Journal of Technology Transfer*, 26, pages 247–254.

Kanter, R (1994), "Collaborative advantage: the art of alliances", *Harvard Business Review*, 72(4), pages 96–109.

Kuhn, T (1970), *The Structure of Scientific Revolutions* (University of Chicago Press, Chicago).

Olson, G M, and J S Olson (2000), "Distance matters", *Human–Computer Interaction*, 15(2-3), pages 139–178.

Orlikowski, W (1993), "Learning from notes: organizational issues in groupware implementation", *The Information Society*, 9(3), pages 237–250.

Robson, C (2002), *Real World Research* (Blackwell, Oxford UK).

Rocco, E, T Finholt, E Hofer and J Herbsleb (2000), "Designing as if trust mattered", in *Proceedings of the ACM SIGCHI Conference*, CREW Technical Report, University of Michigan, available at <http://www.crew.umich.edu/Technical%20reports/Rocco_Designing_as_if_trust_mattered_04_28_00.pdf>, last accessed 9 August 2003.

Salter, L, and A Hearn (1996), *Outside the Lines* (McGill-Queen's University, Montreal, Canada).

Science of Collaboratories (2002), "Summary of the workshop on social underpinnings of collaboratories", 15 March 2001, available at <http://www.scienceofcollaboratories.org/html/Workshops/WorkshopJune42001/FinalSummary.html>, last accessed 9 August 2003.

Strauss, A (1998), *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory* (Sage, Thousand Oaks CA).

Sonnenwald, D H (1996), "Communication roles that support collaboration during the design process", *Design Studies*, 17, pages 277–301.

Sonnenwald, D H, P Solomon, N Hara, R Bolliger and T Cox (2002), "Collaboration in the large: using video conferencing to facilitate large group interaction", in A Gunasekaran and O Khalil (editors), *Knowledge and Information Technology in 21st Century Organizations: Human and Social Perspectives* (Idea Group Publishing, Hershey PA) pages 115–136.

Teasley, S, L Covi L, M S Krishnan and J S Olson (2000), "How does radical collocation help a team succeed?", *Proceedings of the Computer Supported Cooperative Work Conference* (ACM Press, New York) pages 339–346).

Wasserman, S, and K Faust (1994), *Social Network Analysis* (Cambridge University Press, New York).