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STAKEHOLDER INFLUENCE ON DESIGN OF AQUATIC HABITATS

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Summary:
An empirical study was conducted across Washington State to explore the social dynamics of designers and other project participants involved in fish habitat improvement projects. We found compelling evidence of design being a social process that readily accommodated stakeholder needs. Traditional engineering decision making methods were not used in spite of the highly technical nature of many projects.

Keywords: natural resources, design, problem solving

Stakeholder Influence on Design of Aquatic Habitats

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INTRODUCTION

One of the greatest challenges facing engineering and scientific problem solvers is finding ways to fully integrate social complexity and diverse viewpoints of interested publics into their work. Modern engineering decision-making generally developed under a paradigm that included a singular decision-maker or client and single engineer. Only recently has engineering education embraced team and participative approaches to design. Literature on stakeholder involvement and multiple decision-makers is just beginning to emerge. During the last fifteen years a number of public policy and sociopolitical changes have either allowed or encouraged direct public participation in the activities of engineers and scientists. Discipline-based design approaches are being replaced with multidisciplinary and cross-functional team approaches to design and problem solving. Task teams and cross-functional or concurrent engineering teams are frequently assigned rather than self-selected, making society-building a necessary concurrent activity for team members. Technical professionals are generally unprepared to understand or participate in social role and norm development that is critical to team success. Additionally, the technical professions are struggling to discover and develop sensitivity to, and appreciation of, the societal context of their work as well as develop new operating paradigms that are consistent with engineering being as much a social process as it is a technical process.

A study of fish habitat improvement projects across Washington State provides important insight into stakeholder involvement in natural resource engineering projects. This paper reports on the knowledge gained about who the stakeholders are that participate in the design process and how they exert their influence on design decisions.

ENGINEERING DESIGN AS A SOCIAL PROCESS

In spite of its long history of creating artifacts to meet society's needs, engineering is believed by most people to be free of societal influence and "outside the checks and balances of social order" (Vincenti 1991). A proposition of this paper is that the profession of engineering is a social construction; therefore, it is logical that engineering design should be practiced in a broad societal context. There appears to be a general lack of awareness and appreciation that influences external to the firm and design team frequently dominate design decisions. Increasing external public, regulatory and special interest group participation in engineering design comes at a time when the current generation of design engineers is least prepared to appreciate and accept non-technical input (McNeill 1992) (Hughes 1991).

Over the past forty years or so engineering has been positioned by educators and many practitioners as being necessarily independent of, and immune from, social influence (Morrison 1986) (Vincenti 1991). In the mid-1950's engineering education in the United States was directed away from social-technical integration toward more scientific and mathematical content (ASEE 1954; ASEE 1955). At the same time that engineering education stepped away from problem definition and consideration of non-technical aspects of design, the new educational discipline of professional management provided specialists to assume the decision-making roles in society (Chandler 1977). Engineering students were subsequently taught that it was the role of engineering managers and other non-technologists to address politics, external interests and other non-technical design issues (Morrison 1986) (Bennett 1996). However, since the early 1980's we have watched a major shift in the practices of engineering employers to place the burden of addressing non-technical design issues squarely back onto the design engineer. Design engineers are now challenged to directly participate in a broader social system more than at any time in the past four decades.

We have also seen over the last fifteen years an erosion of confidence in engineers by the general public (Ferguson 1992). Many of the attacks on engineering and other technological artifacts appear to arise from newly discovered risks or negative consequences of what was perceived to be highly beneficial technical advances in the past. The rate of change in societal values and expectations may be causing the public to lose sight of the social context within which a technical project was undertaken. The social construction view of technological systems holds that all technological artifacts "bear the imprint" of the social context surrounding their development (Pfaffenberger 1990) (Hughes 1991). A few years after the construction of an engineering work or release of a new product there is little public recollection of the social context that stimulated or constrained its design. While the social construction view suggests that the design of an artifact and society are inseparable another view suggests that engineering methods are consciously or unconsciously disconnected from the processes for problem solving used by the non-engineering society at-large (Adams 1991). It may be that the community of engineers and engineering educators have not taken time to maintain their places in the social systems necessary for the survival of the profession (Bugliarello 1991).

Other forces of change are at work as well. The social institutions that support engineers and engineering employment are undergoing unprecedented change. Employment relationships are in turmoil, with engineering and other service positions bearing a full share of many organization's downsizing and outsourcing movements. Erosion of private property rights combined with increased acceptance of the stakeholder view of the corporation (Carroll 1993) has brought multitudes of stakeholders into the design process, either as participants or reviewers of proposed engineering works. Changes inside and outside the engineering community suggest that it is no longer clear just what the role and place of engineering is in our modern society.

There have been a number of recent studies of the social organization and dynamics within design firms and design teams (Bucciarelli 1988). Bucciarelli's recent work, *Designing Engineers,* explores the inner workings of a number of design teams and organizations (1994). Bucciarelli concludes that the inner workings of engineering firms demonstrate that the practice of engineering is a social enterprise. Bucciarelli noted that the firms he studied were part of a larger system including the financial community, universities, and others, but his focus was internal processes, not the social dynamics of external relationships.

The present study is among the first attempts to systematically explore social organization and dynamics of design teams that are comprised of persons from many different organizations and professional interests. Such design teams are increasingly common in industry where regulators, vendors, outside fabricators, customers and others are all included in, and often numerically dominate, product design teams. In the natural resource industries, complex design teams are becoming the norm. In our project we set out to explore the social network surrounding the design of technical components of select design projects, and how the participants in the social network influenced the specification of design parameters.

METHODS

An ongoing empirical study is exploring how stakeholders influence decision-making by design teams in the natural resources. The current study focuses on design decisions related to fish habitat improvement projects involving small streams. Fish habitat improvement projects typically involve the design and placement of structures within the riparian area and stream channel. Design decisions include specification of material, specification of structure size and shape, location and distribution of structures along the stream, method of placement, and method of anchoring. Each of these design decisions is likely to involve technical as well as subjective analysis. Both the technical and subjective analyses are likely to be further influenced by beliefs and values held by various stakeholders associated with a particular project.

The research is retrospective and covers Washington state projects which were issued permits by the regulatory agencies during 1997. The primary research method is a combination of semi-structured interviews and surveys. Additional detail is collected from permit applications, documentary evidence provided by project sponsors and reports in the media. Data collection revolves around the following questions:

1. What was the design objective (functional requirement) that you were striving to achieve through … (specification of material, choosing method of placement, etc.)
2. Who contributed to or influenced the design process and decision?
3. What were the constraints on how you achieved the objective?
4. Where did the constraints come from?
5. What was the range of alternatives you considered?
6. Where did the alternatives come from?
7. What constraints and alternatives were consciously kept off the table?
8. What was the social network that surrounded the design phase of the project?

The study sample was drawn from project sponsors who recently received Washington State Department of Fish and Wildlife Hydraulic Project Approval (HPA) permits for small stream habitat improvement projects. We are looking for systematic evidence that core team members have processes to identify stakeholders and consciously factor stakeholder input into their design decisions.

DESIGN OF FISH HABITAT IMPROVEMENT PROJECTS

Stream habitat improvement projects necessarily involve collaborative efforts of landowners, agencies, contractors and various special interest groups. Many of the projects are initiated by agencies or interest groups other than the landowner. When someone other than the landowner initiates a project, the stream corridor landowners are recruited or otherwise brought into the project. In other cases landowners initiate habitat improvement projects for their own benefit, then bring agencies and other interests into the project to share costs, provide labor or provide political support favorable to gaining project approval by regulatory agencies.

Habitat improvement projects are generally accepted as having competing interests of bank protection, flood control, civil structures protection, landowner uses, recreational demands, etc. Thousands of small projects have been executed across the United States in the past decade. At least several hundred small stream projects have been conducted in the state of Washington. Through the collective experience of many projects, one would expect that identification of interest groups, development of communication linkages, and establishment of norms for involvement are showing signs of maturity. Social and communication networks involving project designers and stakeholders may be well established in some regions of the state.

Small streams are defined for our purposes as streams having normal summer flows of less than 100 cfs. or channel width less than ten meters. Common habitat materials include concrete, steel, milled wood, automobile bodies, quarry rock, cobbles in gabions, placed logs and placed root wads. The choice of materials is a product of potentially conflicting needs such as cost, aesthetics, fisheries value, availability of materials, regulatory requirements and landowner preferences. Participants in the materials decision are likely to include the landowner, design firm, materials supply firms, regulatory agencies, environmental special interest groups, fisheries special interest groups, and installers.

Structure size and shape involves a trade-off of materials cost, placement difficulty, stream channel characteristics, hydrologic regime, and effectiveness for creation of fish habitat. The location and distribution of structures along a stream typically is affected by stream access issues, project budget versus technical optimal habitat creation, balancing of creating new pools versus reinforcing existing pool habitats, desire to modify the stream direction, etc. Method of placement ranges from hand labor to heavy equipment, cranes, logging skylines and helicopters. Tradeoffs include project budget, availability of labor, size of materials, environmental sensitivity and site accessibility. The method of anchoring can include choices to do nothing, drill and epoxy anchors into the streambed, tie cables from the structures to riparian trees, driving piles or structural elements into the stream bank and weighting the structure with large rocks.

In all of the above decisions there is the potential for dominance by value judgments, preferences of central stakeholders, and scientific/cultural norms that support one technical or analytical paradigm over another. We are attempting to identify the source of influence on design decisions during the course of the study.

Observations are being compared and contrasted across projects within a sponsor type and between sponsor types. We expect to find wide variation in stakeholder involvement practices within and between sponsor types. We will be able to describe and draw conclusions about how a limited number of designers and design teams practice stakeholder involvement. Exploration of the source of differences may lead to new understanding and ideas about how to improve stakeholder involvement training or processes. Hopefully, the resulting characterizations of similarities and differences will stimulate future research into 1) how stakeholders are involved in other design problem types; 2) other employer types; other geographical regions; and other natural resource industries such as agriculture.

RESULTS

The study covered fifty-one in-stream habitat projects on twelve watersheds in Washington State. Project size ranged from very small landowner initiated projects to multi-million dollar construction projects. Over ninety individuals associated with the projects were interviewed by phone or in person. More than thirty-five project sites were visited so materials and methods could be assessed. Most site visits were guided by one or more project participants. Their presence allowed unstructured exploration of reasoning behind many of the design decisions made by the project designers.

We were able to identify most project participants through snowball sampling (Biernacki and Waldorf 1981) starting with project sponsors and others listed on the HPA permit application filed with the Washington Department of Fish and Wildlife (WDFW). The number of project participants ranged from three to seventeen, with 5 – 7 participants most typical. Not all project participants were directly involved in design decisions. However, most projects had at least three persons identified as influencing design decisions. A few projects followed the traditional model of an arm’s length relationship between designers and other project participants. However, this was rare in our sample.

The roles most often identified with project participants include:

- Landowner / Project Sponsor
- Funding Agency – FEMA, Conservation District, etc.
- Project Manager / Coordinator
- Designer
- Technical Participants – Engineer, biologist, ecologist, hydrologist, geomorphologist, etc.
- Regulator(s) – WDFW, Dept. of Ecology, US Army Corps of Engr., etc.
- Contractor / Work Crew

In many projects an individual might be associated with multiple roles. For example, the project manager might also be the lead designer and the landowner may also be the contractor. One finding that is relevant about roles is that participant roles were fairly easy to identify and were apparently well understood by other participants. The clarity of roles was a bit perplexing since most project "teams" were ad hoc and virtual. By that we mean that project teams tended to come together through a poorly structured affinity process, execute a project and then disband. Team membership changed dramatically from project to project within a watershed (except for rural eastern Washington). Snowball sampling was necessary to discover project and design participants because no one, including the project manager, was able to identify all project participants in a majority of the projects studied. Participants knew those persons they interacted with to do their part of the effort, but did not know or attend meetings with other participants. The virtual team notion is supported in that the team structure exists only as an artifact of our investigation and mapping of relationships.

We expected to find that stakeholders who did not have personal ties to project team members would participate via public involvement processes such as SEPA reviews or letters to permit agencies. We found no evidence of project design influence by special interest groups and private citizens. In effect, influence was via direct participation, negotiation and personal relationships. When we probed into the reasons behind the lack of participation and influence by indirect means, we found that most project managers encouraged it, but no response was received.

We expected to find that stream restoration and habitat practitioners would have well-established networking mechanisms. Although we identified over 200 participants in our study sample, we found that only a few had any contact with practitioners, engineers or technical specialists from outside their own watershed. The only technology and design ideas transfer agents we could identify were the WDFW Area Habitat Biologists and USDA –NRCS specialists. Both of these professional jobs entail participation in multiple projects within a region, and the individuals who hold these positions tend to be transferred around the state during their careers. Although we identified these two positions as central to the social networks and the only available explanation for idea dissemination, the individuals we interviewed in those positions tended to downplay or disavow their technology transfer role.

We asked all project designers to list the reference works an experts who influence how they approached design decisions. We found that only about ten percent of those involved in design decisions had ever read one or more of the design guides on the market or ever attended a training workshop. It was very clear that design expertise was developed through experience within the watershed.

We probed to discover the level of influence that the Washington Administrative Code that covers habitat projects (WAC 220-110) exerts on design decisions. Outside of the regulatory agents, we found little familiarity with the code and its' prescriptions with respect to design.

The subset of roles most often identified as influencing design decisions (in decreasing order of frequency) include:

- Funding Agency
- Project Manager/Coordinator
- Regulator(s)
- Designer
- Contractor / Work Crew

The funding agency has a huge influence on design. If the funding agency is FEMA then the project goals and constraints are dominated by flood and public works protection. If the funding agency is a conservation district then we found that the NRCS field guide and standard drawings controlled most design decisions. If the funding agency was a county surface water management agency then bank protection or conveyance tended to dominate the project design. In most of the projects funded by such agencies habitat features were introduced as mitigation or secondary objectives. When the funding agency was devoted to habitat creation or enhancement, then the projects took on a decidedly different flavor. The habitat objectives took center stage, and bank protection, property protection and other objectives were added to satisfy landowners, neighbors and other influential stakeholders.

The influence of the project manager is to be expected. From the earlier discussion about the ad hoc and virtual nature of the project teams, it should be apparent that the project manager is in a central position for control of information and decisions. We found that the project manager usually had the most experience with organizing and designing habitat projects. The combination of leader-authority and relevant experience was borne out in influence level. However, the project manger was very sensitive to the needs and biases of other key participants. Projects were often framed in ways to garner approval from potentially blocking stakeholders or support from funding agencies.

The regulator’s influence on design was most often exerted through enforcement or interpretation of the state codes covering in-stream habitat projects. Some regulators also perceived their role to include coaching and advising inexperienced project managers and designers or effective design of projects.

The designer’s influence was marginal in most cases where the designer’s task was plan preparation for permit approval. However, when the designer was a consultant, engineering specialist or project manager, then the level of influence was high, but not absolute. Designers had to be sensitive to and incorporate features necessary to satisfy other stakeholders.

Contractors and work crews had fundamental control over how the projects were executed. In many cases the design simply specified that X number of logs or root wads or rock barbs should be installed along Y feet of stream. Drawings were of typical sections and left the actual methods of placement, anchoring and arrangement to the work crews. We frequently heard that the experience and creativity of contractors or work crews can make or break a project.

We probed to discover what sort of design processes were followed by engineers, designers and project managers. We found that none of the design participants were comfortable characterizing their design process as procedural, rational, or standard. None of the designers we interviewed were familiar with Quality Function Deployment (Guinta and Praizler 1993) (Ullman 1992) or Suh’s principles of design (Suh 1990). We were unable to discover a coherent design process for any of the projects we studied. This is not to suggest that projects were not successful. All of the projects we visited appeared to be functional and delivering on the objectives described in either the HPA permit or as framed by participants during our interviews.

DISCUSSION

From a classical engineering design and team process viewpoint, it is not apparent how very many of the projects we studied could be successful. There were no formal design processes and design optimization algorithms. There was no formal team building. It was rare that all project participants even knew one another. Yet, the designs we saw were adequate to receive landowner, funding agency and regulatory approval as well as meet stated project objectives. We were left with a number of questions about how doing design in the natural resources really works.

- Would we expect procedural design methods to produce better designs with respect to cost, logistics and goal satisfaction?
- How do ad hoc, virtual teams organize and achieve their goals?
- What are the mechanisms for mutual learning and technology transfer across projects?

One explanation for why formal design processes were not followed is the observation that few projects were led by a trained engineer. Only engineers receive education in procedural design methods. Other professional disciplines tend to follow problem solving or participatory decision making processes when faced with “design” problems. In order for processes like QFD and Suh’s principles to have much effect on how habitat projects are executed, the methods would need to be delivered to and accepted by the majority of project participants who have other technical or non-technical backgrounds.

It appears that multi-disciplinary, cross agency projects adopt a team model that is only just now being recognized. The basis for team membership, conflict avoidance, and role clarity appears to be professional respect and shared goals. The goals of a habitat project are clear from the outset. Only those skills, competencies and stakeholders necessary to achieve the goal appear to be brought into the project. Project participants, including the project manager, trust other project participants to do their job well and link to resource specialists they need to support them. This form of organization was recently characterized as an “intellectual web” or “spider’s web” (Quinn, Anderson, and Finkelstein 1996). The notion of a spider’s web form of organization is based on networking rather than organizational matrices. The project manager knows three or four key persons who need to be involved in the project. Each of those persons knows others who are needed for more niche roles, and so on.

Another apparent key to success in this unstructured approach to design is the ability of key participants to rapidly identify who the key stakeholders are and figure out how to weight their conflicting needs during decision making. Mitchell, Angle and Wood (1997) called this “the principle of who and what really counts.” This notion is supported in our finding that most project teams had an efficient 4-7 participants, yet the list of potential participants could easily top a dozen or more. If critical stakeholders were excluded from project decision making we would have expected to see written testimony in the public comment files, or heard tales of threatened legal actions, etc. Such evidence was not present in our study sample.

Weighting of the conflicting needs of various participating stakeholders was almost universally characterized as a process of mutual learning, negotiation, brinksmanship and/or accommodation. The processes used were all social processes. In several projects there was concern about engineers and other technical specialists not being sensitive to the give and take of negotiated decision making and uncomfortable with the notion of design as a social process.

CONCLUSIONS

We found compelling evidence that design of fish habitat projects in Washington State is a highly social process. Project participants represent a wide range of disciplines and agencies, each with a different culture and set of objectives / constraints to be satisfied during the project.

Decision making with respect to design elements (materials, placement, anchoring, etc.) was either through deference to an expert or via social processes. We found no evidence of analytic optimization, systematic exploration of alternatives, or other formal design methods.

This project stimulates a need to further explore:

1. how engineers can become more effective in spider's web forms of project teaming, and
2. what design methods are best applied to projects where the team is dominated and/or led by non-engineers.

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