Ancestral Engineering: Towards the Integration of Archaeology and Engineering

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Abstract

We have long felt those who modern society has named "Engineers" have played a significant role in the evolution of cultures and civilizations. Working with manual tools and the materials that nature provided, historical evidence has proven that practical, innovative, and esthetically beautiful creations emerged from our engineering ancestors. As with most effective research, understanding the past can lead to optimizing the future, and we propose that it is beneficial to study engineering and design in this context.

In this paper we will discuss what we have termed "Ancestral Engineering", and describe the rationale behind the initiative. Two main themes have emerged; engineers helping archaeologists to integrate engineering expertise into their investigations, and archaeologists helping engineers to extract engineering design practice and methodology from other cultures. Within this framework, several initial project ideas are discussed and a suite of Research Questions is proposed.

We believe this is an emerging field, with significant opportunity to develop collaborative relationships with interested engineers, archaeologists and anthropologists to pursue discussions and potential research in this field.

1. Introduction

As engineers and designers, we have long felt that so-called "primitive" artifacts often have a sophisticated design behind them. These technologies and designs worked and they worked well.

"Native American technologies are highly 'evolved', the product of thousands of

years of expertise, oral traditions, change and continuity. There is nothing crude or rudimentary about them, there is nothing self-taught or untutored about them. ... (they) are all very difficult technologies to master and require intelligence, practice, skill, patience and teaching to be proficient at them" [1].

Similarly, Olive Dickason in her seminal work on First Nations history describes a continent of extensive civilization, culture and technology prior to European Contact. She includes a mature stone tool technology, possibly the highest expression of Stone Age technology [2].

Older technologies were also built without access to modern materials or power technology, adding additional constraints on the design. This only enhances the achievement from a design point of view. It is our belief that the study of these designs, and the methodologies used to produce them, can offer significant insights into the design process. We propose to initiate study into Aboriginal design practices and processes.

An example is that of Aleut/Inuit deep-sea whaling technology. The technology was the most advanced in the world and was adopted by North West Coast First Nations people, noted deep-sea whalers themselves [3]. Prior to the arrival of the English and French, Basque whalers also adopted the technology, as did the French in turn [4]. A particular challenge is the complexity of design in many of these technologies. The birch bark canoe and the Inuit skin boat, or kayak, and the igloo are three notable examples.

While there are a myriad of examples from around the world, we have chosen to restrict our initial scope to the First Nations of the Northwest Coast of North America. The Northwest Coast is a small unit, compared to the whole world, or even North America. It is well-defined and easily

accessible for research, both in the library and directly [5, 6]. McMillan and Yellowhorn describe a rich, complex society based on abundant resources, most importantly salmon and cedar, with a sophisticated technology, a high level of artistic achievement and complex social structure. It is also one of the few cultures to achieve this level of civilization as a hunter-gatherer society [7]. There are many good examples for study, such as canoes, houses, bentwood boxes, whaling gear and carving tools. Hilary Stewart describes the technology of the Northwest Coast in detail that immediately catches the eye of a design engineer [8, 9, 10]. There are also many other good sources, and the sophistication of the culture and art is well acknowledged.

We believe that results obtained from studying the Northwest Coast will have relevance when studying other cultures world-wide. The Native Access to Engineering Programs initiative and Corinne Jette introduced the term “Ancestral Engineering” into general usage [11, 12]. We have chosen to adopt this very appropriate term for our area of study interest.

2. Current Work

There have been some initial approaches to studies of First Nations (and other) technologies. Some work has been done in the currently popular field of experimental archaeology. This is the recreation of artifacts, mainly tools, from original materials and the attempt to relearn ancient techniques. Tim Severin has voyaged across the Atlantic in an ox-hide-covered, oak-framed boat as St. Brendan is reputed to have done [13]. Kevin Brownlee of the Manitoba Museum has reconstructed part of the Northern Cree hunting kit [14]. Some Materials Science research has been done, mainly on ancient ceramics, for example, in *Materials Issues in Art and Archaeology* [15]. A few studies have been done using business and other models to help understand the cultural process of production [16].

Our proposal differs in that we intend to go beyond this work to evaluate designs and to attempt to extract design methodologies. The only other work we are aware of which addresses any aspect of design is that of Peter Bleed, which evaluates optimal design in Stone Age hunting tools in terms of maintainability as opposed to reliability [17].

3. Integration of Engineering and Archaeology

Two main themes have emerged from our initial endeavors. The first involves engineers helping archaeologists; to attempt to integrate engineering expertise into archaeological and anthropological investigation. The second involves archaeologists helping engineers; to attempt to extract design methodology and engineering practice from the past, particularly from non-European cultures.

One may easily argue that engineers, formally trained or otherwise, have a significant role in the evolution of cultures and civilizations. This is certainly true for our own culture. It follows then that if one wishes to study another culture and civilization, it is necessary to study its engineering as a cultural activity. In order to do so properly, there needs to be archaeological, anthropological and engineering expertise cooperating in the study.

The second theme, extraction of design methodologies, we feel may be of great value for future engineering practice. While we are restricting ourselves to Northwest Coast culture at the moment, there should be application across many cultures, both other First Nations and non-North American cultures. We believe that the process, when extracted, will prove to be *not* trial-and-error, as is conventionally thought. Rather, it will consist of creative questioning of designs, observations of “performance”, and then modification based on these activities in an iterative process analogous to modern design.

Another aspect to this theme, at least in the case of North America, is the spirituality and respect for nature inherent in Ancestral Engineering. We believe that concepts of design which encompass the ideas of minimizing resource consumption, return of the resources to the environment, and minimizing the impact on the planet, will be critical to future engineering practice.

At this stage it is necessary to develop a body of knowledge related to ancestral engineering in this context. A key element is to establish engineering as a cultural activity, and to recognize the differences in practice between cultures. A second goal is to determine whether alternative engineering design methods can be effectively applied to the solution of current societal challenges, especially with respect to the sustainable use of resources. We have developed a preliminary series of research questions and

potential outcomes proposed for the study of Ancestral Engineering.

We also believe that the project should have extensive First Nations input. We feel that all products of the project should be reviewed by First Nations persons. In this, we are following the examples of *Yuquot Agenda Paper* [18], the *Kiix'in Agenda Paper* [19] and Kevin Brownlee [20]. In essence, these papers detail First Nations projects in which there was a conscious effort at returning control of First Nations history and the telling of the history in an academic setting to the First Nations involved and fostering pride in their accomplishments. The agendas in these cases was set by those First Nations and carried out by First Nations people and academics in cooperation. Even though we may not be able to achieve the same level of integration, we intend to honour the spirit of the cooperation outlined in the papers.

4. Research Questions

Our questions are four in number. For each we will pose the question, put forth a goal and discuss potential research methods. We will also indicate what we see as impacts of the research for the First Nations.

We shall address our two themes in reverse order. The first three questions address the theme of extraction of design methodologies.

I. Methodologies

What methodologies were used by aboriginal cultures in the process of designing their engineered products, both objects and systems? The goal is to understand ancestral design methodologies and acknowledge and document engineering practices of aboriginal cultures. To do this we propose to:

- Document and classify aboriginal engineered products, especially those prior to first contact.
 - Engage aboriginal communities in the description of design processes.
 - Document aboriginal design methodology using reverse engineering and design case studies.
- For the First Nations, a greater understanding of aboriginal engineering practices will enhance recognition of the community as a highly developed culture.

II. Differences

Are there fundamental differences between aboriginal and current design methodologies? There are two goals here. Differences in design methodologies may indicate why cultural

differences in products exist. A distinct methodology may provide alternatives to current engineering. These will be reached by comparison of contemporary and aboriginal methodologies using a variety of design models and assessment of the impact of aboriginal product design using environmental, life cycle, economic, social, and sustainability measures. We believe that this will result in recognition of the uniqueness of Aboriginal engineering practice and that Aboriginal design practice will be recognized as a *bona fide* methodology for product design

III. Contemporary Value

Can aboriginal design methodology be usefully applied to contemporary technical challenges? We hypothesize that the former is based on a sustainability model, which may have significant implications for future engineering practice. We believe that assessment of novel product designs using both aboriginal and conventional design methodologies will indicate the practicality of each approach in a contemporary context.

Combinations of design approaches may result in unexpected or synergistic designs. Such a distinct methodology may provide alternatives to current engineering practice in which sustainability is fully integrated into design. These goals will be reached by several methods:

- Identification of benchmark technical challenges with significant sustainability issues
- Application of aboriginal design methodology to the benchmark challenges
- Assessment of design outcomes in comparison to conventional solutions
- Documentation and analysis of current solutions, and application of current design techniques to identify possible new solutions.

For First Nations, the applicability of aboriginal design techniques to current engineering practice will be recognized. Aboriginal community members may be encouraged to become more engaged in engineering practice.

Our fourth question addresses the first theme.

IV. Integration of Archaeology and Engineering

Can engineering methodology be integrated into archeological practice and *vice versa*? The goal is simple, to bring engineering and archaeology closer together. We propose that pilot projects be initiated involving different types of engineering

analysis applied to a variety of artifacts to assess their suitability to perform their assigned function. From a philosophical point of view, we propose development of a contextual view of ancestral engineering within its society.

5. Research Plan

An approach used in the anthropological study of aboriginal technologies is to analyze the relationship between function and form. In engineering design, this is often separated in terms of user requirements [function] and engineering specifications [form]. Structured methodologies such as Quality Function Deployment [21] have been successful in improving product design so that functional requirements are satisfied through effective control of such factors as material properties, geometry, etc. A key to this is the unbiased extraction of functional requirements from the user community. In many applications, this is an extensive process requiring rigorous techniques and a broad range of observers beyond the engineering viewpoint.

Extraction of functional requirements and engineering specifications with respect to ancestral engineering design practice presents a number of challenges. First, cultural differences exist with respect to descriptors and values associated with these factors. Second, the access to this information may be limited to certain members of the aboriginal community and, appropriately, not be available for analysis outside this group. Finally, there may be dimensions beyond function and form that are intrinsic in the design that are not obvious. These dimensions may include linkages with the past, concordance with the environment and other spiritual aspects of the community. This prospect is particularly interesting since these considerations are largely absent in conventional engineering design practice.

We are working to establish contacts in the archaeology, anthropology and engineering communities. We are also beginning to establish links to the First Nations. The Queen's University Aboriginal Council has voted to support the Project. We have begun a search for First Nations associates.

We have located the Adams canoe [22] at the Canadian Canoe Museum in Peterborough, Ontario. We hope to obtain detailed measurements. If successful, the canoe will be modeled and analyzed for its effectiveness as a boat. Should this prove useful, other analyses would be a logical follow-up.

There is also a possibility of modeling the mechanisms and shoulder harness of transformational masks, then using dynamic motion analysis to evaluate their efficiency. Both these projects will also enable us to investigate and evaluate the particular engineering tools for their appropriateness in this context. We are also investigating the possibility of using a Stereolithography Scanner as a measuring tool in this and other projects.

We would like to do careful measurement of tools for comparison with modern equivalents. One example is chisel blades, both stone and shell. Such analyses may lead to reexamination of tools in museum collections and reevaluation of previously assigned functions of such tools [23]. Another project following from this would be to recreate traditional tools and apply them to traditional tasks such as carving (e.g. totems, canoes, boxes) and evaluate their performance. This type of study would be accomplished in two ways, the analysis of the artifacts and the reconstruction of the artifacts using appropriate (both historical and modern) technologies. As an example, bentwood boxes could be done by first building a box using any convenient method, probably using mostly modern hand tools. The next step would be to recreate ancient tools and build a box using only historical methods. This would allow evaluation of both box technology and tool technology and may also involve materials analysis.

Following on from the canoe analysis mentioned above, we should talk to current carvers and elders to determine *why* canoes are and were carved in the shape they were. There is a unique opportunity here in that there was a large lacuna in the carving of canoes. In the course of some eighty years, much of the engineering expertise was almost lost. The Great Canoe revival [24] presents a unique opportunity to study the recapture of a particular body of engineering knowledge and expertise, namely the design of the great canoes. The study of the 1908 war canoe at the Museum of Civilization in Hull, the Adams canoe, Bill Reid's *Loo Tas* and discussions with those involved in the Great Canoe revival may provide valuable insight into the traditional design process. This is a large project and one where appropriate First Nations involvement is absolutely necessary.

Finally, we would like to investigate the acoustic qualities of box drums. This could be an initial stage in the investigation of many of the musical instruments

We are currently in the process of developing collaborative relationships with interested researchers to pursue discussions and potential studies in this field. We encourage those interested in this area of research to contact the authors.

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