A framework for sustainable whole systems design

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A whole systems approach, considering the interrelatedness of both problems and solutions, can help create more sustainable designs. Still, designers often apply exclusively reductionist approaches to generate designs. One way to address this issue is to reduce ambiguity in the whole systems approach. This paper describes research to define and unify elements of whole systems design. Elements were identified through a methodical review of sources describing theories, perspectives, and practices from multiple design disciplines. These elements were coded and then organized using concept mapping. The resulting framework has 20 elements categorized as processes, principles, and methods. This framework is meant to help enable more widespread application of whole systems design in practice.
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The challenges we face as a society, and therefore as designers, are significant. These challenges include shortages of energy, natural resources, water, and food; war and political instability; rising levels of poverty, homelessness, and disease; and slipping quality of education and infrastructure. At the same time, current world population is around 7 billion and is projected to reach 10.1 billion by 2100 (Kaiser, 2011). Rapid population expansion accelerates the strain on natural resources and energy, magnifying the impact we have on the health of the planet that supports us.

Carbon footprint is one way to illustrate humans' impact on the environment. It is quantified by converting our use of fossil fuels (e.g. for electricity, heating, and transportation) to metric tons of carbon dioxide emissions (Carbon Footprint, 2011). Carbon footprint is associated particularly with the issue of climate change; the higher the carbon footprint, the larger the contribution to global climate change. There is a worldwide target to combat climate change of 2 metric tons per person per year (Carbon Footprint, 2011). Worldwide, we are twice as high as this target. In the U.S., we are ten times as high (Massachusetts Institute of Technology [MIT], 2008). Carbon emissions are

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just one example that our current trajectory is not sustainable, which will negatively impact the ability of future generations to meet their needs.

Yet, sustainability is not just about future generations. Many people alive today are unable to meet their own needs. Three in every four people residing in rural areas in developing countries are living on less than a dollar a day and suffering from malnutrition. In 2005, one in three urban dwellers (approximately 1 billion people) were living in slum conditions (UN, 2007). The challenges extend beyond poverty to social infrastructure like education: based on enrollment data, approximately 72 million children of primary school age in the developing world were not in school in 2005. Of those 72 million children, 57 percent were girls (UN, 2007).

Addressing these challenges requires changes in how we design our world. We must consider the interrelatedness of systems. The problems we face are intertwined and effective design solutions will have to account for this reality. For example, consider an engineer tasked with alleviating congestion on a city road. Guided by traditional design theory, they would consider adding more travel lanes, or constructing a new street through an existing neighborhood. However, this reductionist approach can be ineffective or even have the opposite effect of its original intent. Adding a new lane of traffic or building a new road can make travel more convenient, which can increase automobile traffic, meaning traffic conditions further deteriorate. Building new streets for automobiles can harm neighborhood connectivity and local businesses, and also lead to more air and water pollution. A more holistic approach to the problem may consider ways to reduce the number of personal automobiles on the road perhaps by reducing travel lane width and adding accommodations for pedestrians, bikes and mass transit. Measures like these have been shown to reduce or handle current traffic patterns, while improving the safety, walkability, and economic vitality of neighborhoods (National Complete Streets Coalition, 2011). Of course, this may not be the solution for every situation, but examples like this show that solutions are possible. To create them, we will have to break down silos, work across disciplines and change our perspectives.

Whole systems design is one approach to sustainable design offering great potential, however the processes, principles, and methods guiding the whole systems approach are not clearly defined or understood by practicing designers or design educators (Charnley, Lemon, & Evans, 2010; NSB, 2007). The Rocky Mountain Institute (RMI) discusses whole systems design as follows:

> "*Whole-system designers* optimize the performance of buildings, vehicles, machines, and processes by collaborating in diverse teams to understand how the parts work together as a system, then turning those links into synergies. *Integrative design* optimizes an entire system as a whole, rather than its parts in isolation. This can solve many problems at once, create multiple