

User requirements for analogical design support tools: Learning from practitioners of bio-inspired design

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When designers develop biologically-inspired design (BID) solutions, they are engaging in a process of analogical design. Software tools have been developed to support analogical design processes, presenting designers with information to help in the construction of useful analogies. However, the requirements for such tools have not been explicitly informed by accounts of practitioners' experiences. To address this, interviews were conducted with 14 expert practitioners in BID to understand how they find and apply cross-domain analogies. Three main themes emerged from the analysis: (1) the skill sets of individual practitioners; (2) the ways they work as part of an interdisciplinary team; and (3) their orientations to biology. These themes present opportunities and challenges for developing analogical design support tools.

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Analogical thinking involves the transfer of information from one domain (the source) to another domain (the target). This is widely considered to be an important process in creative design and innovation (Chan et al., 2011; Dahl & Moreau, 2002; Enkel & Gassmann, 2010; Herstatt & Kalogerakis, 2005; Kalogerakis, Lüthje, & Herstatt, 2010). Biologically-inspired design – BID (also referred to as biomimetics or biomimicry) is a good example of this as it is a design practice which involves identifying and applying analogies from the biological domain to the technical domain. To assist with BID processes, design researchers have developed computer support tools that store and present information about biological and technical systems, so that possible connections can be identified. However, these analogical design support tools have seemingly been developed based on limited information about real-world user needs. Instead, they are primarily based on theory (from multiple fields), student BID projects (with or without access to information tools) and historical anecdotes (often quite brief accounts).

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To better understand the requirements for analogical design support tools, we here report on an interview study of professional BID projects. We discuss the expectations that BID practitioners have for software tools by addressing three main levels of analysis in relation to BID practices: the skill sets of individuals involved in BID; the ways in which individuals work together as part of interdisciplinary teams; and the ways in which those individuals or teams orient towards biology. We show the ways in which software tools could be employed at all three levels in order to support BID processes, and we illustrate the variety of BID processes that might be relevant. These findings advance our understanding of analogical design and our understanding of the requirements for analogical design support tools. Ultimately, by exploring these requirements we intend to provide a more solid foundation upon which analogical design support tools can be developed and deployed.

1 Literature review

Analogical transfer is useful when there is some similarity between the source and the target domains (or the relations in those domains) and where that similarity permits reasoning across domains (e.g., [Gentner, 1989](#); [Vosniadou & Ortony, 1989](#)). Where the source domain is familiar and accessible, drawing analogies can make new subjects easier to understand, facilitating the discovery, development, evaluation and exposition of (natural and social) scientific knowledge ([Holyoak & Thagard, 1995](#), pp. 191, 209). Consequently, analogies are prominently used in many professional practices, including science ([Oppenheimer, 1956](#)), medicine ([Clarke, 1978](#)), management ([Bingham & Kahl, 2013](#)), and education ([Dupin & Johsua, 1989](#)). Analogical thinking is also central to much design activity, where it serves in identifying and solving design problems and in explaining design concepts to others ([Christensen & Schunn, 2007](#)). Collectively, these aspects of analogical thinking provide the opportunity to generate creative design proposals that lead to innovative products, systems, and services ([Chan et al., 2011](#); [Dahl & Moreau, 2002](#); [Hey, Linsey, Agolino, & Wood, 2008](#); [Kalogerakis et al., 2010](#)).

One of the most difficult challenges in constructing analogies is the retrieval of a plausible source, especially where the search space is large and where the relationship to the target is not obvious ([Holland, 1986](#), pp. 288–289, 312). Such challenges have led to suggestions that it is helpful to have a catalogue of possible sources to draw from and some means of identifying those sources that are related to the targets that are being considered ([Linsey, Wood, & Markman, 2008](#)). In response to this need, design researchers have developed computer support tools that assist in the construction and application of both cross-domain analogies (e.g., [Chakrabarti, Sarkar, Leelavathamma, & Nataraju, 2005](#); [Shu, 2010](#); [Vattam & Goel, 2011](#); [Cheong & Shu, 2012](#), pp. 373–382; [Goel, Vattam, Wiltgen, & Helms, 2012](#)) and within-domain analogies (e.g., [Barber et al., 1992](#); [Maher, Balachandran, & Zhang, 1995](#); [Pearce et al., 1992](#)).

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