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GUEST EDITORIAL

Analogical thinking: An introduction in the context of design

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Analogical thinking is a core process of design thinking. This is because design is a cognitive activity (e.g., Cross, 2004; Visser, 2006), and analogy is a core process of cognition (e.g., Hofstadter, 2001; Thagard, 2005). Of course, design is a very wide-ranging and open-ended cognitive activity. For example, design typically is situated in and distributed over the physical world (e.g., design materials), the information world (e.g., design libraries) and the social–cultural worlds (e.g., design teams). Yet, theories, techniques, and tools of analogical design (sometimes also called design by analogy) so far have been much more limited. If we look at the current theories of analogical design, they do not fully capture the range and variety, or the open-endedness and richness of design. Goel (1997) presents an early analysis of cross-domain analogical design, and Goel and Craw (2005) provide a more recent review of within-domain case-based design.

Thus, this Special Issue of *AI EDAM* on analogical thinking has three goals. First, it seeks to explore and use current theories of analogy to understand design as a cognitive activity. Second, it seeks to identify new problems in design for spurring the development of new theories and techniques of analogy. Third, it summarizes the current state of the art in analogical thinking in design and engineering at the end of 2014. The Special Issue contains seven highly refereed papers that represent a subset of all initial submissions. Each paper went through two rounds of reviewing and revision. After the first round, we culled all submissions down to nine papers and invited their authors to revise their papers. After the second round of reviewing, we further pruned the papers to just seven; we recommended the other two good papers for a regular issue of *AI EDAM* because they were not quite ready for this Special Issue. We also requested authors of the seven extant papers to significantly shorten their articles to fit into the Special Issue.

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In the first paper, "Using Analogies to Explain Versus Inspire Concepts," Amanda Chou and L.H. Shu consider two roles of analogy in design: explanation and inspiration. They first describe an empirical study of the use of analogy for explanation in design education. They then analyze the implications of the first study for the use of analogies for inspiration in conceptual design. The latter analysis occurs in the context of biologically inspired design, and it focuses on the designer's familiarity with source cases, the quality of the source cases, and the degree of alignment between the sources cases and the target problem.

In the second paper, "An Empirical Understanding of Use of Internal Analogies in Conceptual Design," V. Srinivasan, Amaresh Chakrabarti, and Udo Lindemann report an empirical study of internal analogies in conceptual design, where an internal analogy is an analogy based on the designer's own memory. They describe several findings, including these four: designers use analogies from both natural and artificial domains, designers use the analogies for generating both design requirements and design solutions, the nature of the design problem influences the use of analogies, and analogies from the natural domain lead to a larger number of design ideas as well as a larger variety of ideas.

The third paper, "Representing Analogies to Influence Fixation and Creativity: A Study Comparing Computer-Aided Design, Photographs, and Sketches," by Olufunmilola Atilola and Julie Linsey, situates design in the external world. It describes an empirical study that examines the influence of external representations of source cases on design fixation and creativity: computer-assisted design drawings, sketches, and photographs. The authors found all three representations to induce fixation. They also found that computer-assisted design drawings offer the most advantages for generation of design ideas by analogy and sketches the least.

The fourth paper, "How Do Analogizing and Mental Simulation Influence Team Dynamics in Innovative Product Design?" by Hernan Casakin, Linden Ball, Bo Christensen, and Petra Badke-Schaub, situates design in the social world. It describes an empirical study that examines the influence of analogical thinking and mental simulation on team dynamics

in product design. Their findings indicate that both analogical thinking and mental simulation, and especially the latter, correlate with team collaboration and team cohesion.

In the fifth paper, "Interpretation-Driven Mapping: A Framework for Conducting Search and Rerepresentation in Parallel for Computational Analogy in Design," Kazjon Grace, John Gero, and Rob Saunders present a framework for reinterpretation of analogies. In this framework, the process of constructing an analogy between a design problem and a source case entails iterative and parallel interactions between mapping and interpretation. The authors also describe a computational implementation of their framework.

In the sixth paper, "Information and Interaction Requirements for Software Tools Supporting Analogical Design," Gülşen Töre Yargın and Nathan Crilly examine the requirements for developing interactive tools for supporting analogical design. They propose that the requirements can pertain to either the information content that the tools provide or the interactions that the tools support. They recommend that interactive tools developed should pay special attention to open-endedness and accessibility to be useful for supporting analogical design.

The seventh and final paper, "On the Benefits of Digital Libraries of Case Studies of Analogical Design: Documentation, Access, Analysis, and Learning," by Ashok Goel, Gongbo Zhang, Bryan Wiltgen, Yuqi Zhang, Swaroop Vattam, and Jeannette Yen, describes an interactive tool called Design Study Library that provides access to a library of case studies of biologically inspired design. Initial experiments with Design Study Library indicate that it may support analogical learning of the processes of biologically inspired design.

We thank the reviewers who helped review the original set of submissions to the Special Issue. We especially thank the reviewers who reviewed nine papers twice. This Special Issue would not have been possible without their thoughtful critiques. We are grateful to the *AI EDAM* Editor in Chief, Professor Yan Jin, for his encouragement and support for the Special Issue. We are also grateful to Professor David C. Brown, *AI EDAM* Editor Emeritus, for his advice. This Special Issue has taken considerable time, thought, and effort; and we hope that this is evident from the papers contained within it.

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