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## BIM-based collaboration across organizational and disciplinary boundaries through knotworking

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### Abstract

Knotworking is introduced as a new idea and an emerging practice for enhancing collaboration across organizational and team boundaries in BIM-based building projects. Knotworking refers to co-located ‘knots’ that are organized on a temporary basis to solve a specific task, a problem or an open question requiring multi-disciplinary expertise in a building project. The idea of knotworking was adopted and re-interpreted from elsewhere in a research and development program in the Finnish construction industry and experimented with in the early design of a school building. The aim of this study is to examine how the fragmentation of design and construction work could be reduced through knotworking in building projects. The methodology of the study is based on developmental and interventionist approaches in activity theory (Engeström 2014; Miettinen et al. 2013), according to which the developmental processes are carefully followed, analyzed and documented. Complex problems such as “waiting” and “decision-making” motivated the practitioners to experiment with knotworking in the program. The experimentation required thorough prior preparation in the development of knotworking. The new knotworking concept, using the best existing technology, enabled the creation of 15–20 energy solutions and cost calculations for five architect scenarios in a two-day knotworking workshop. The method was further tested in three other cases during the program, and it was presented to relevant stakeholders at several events.

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## **1. Introduction**

Knotworking is introduced here as a new idea and an emerging practice for enhancing collaboration across organizational and team boundaries in BIM-based building projects. In knotworking, co-located ‘knots’ are organized on a temporary basis to solve a specific task, a problem or an open question requiring multi-disciplinary expertise in a building project. The stakeholders, specialists and experts required for conducting the task are invited to participate in a ‘knot’. These ‘knots’ last usually one or two days, and several knots can be arranged during a project. After the task is accomplished, the ‘knot’ dissolves. The idea of knotworking was re-interpreted from previous health care projects (Engeström 2008) and adopted to a development program in the Finnish construction industry (Kerosuo et al. 2013). In this program, knotworking was experimented with in the early design of a public school, the object of which was to provide design alternatives for the client’s decision-making. The new knotworking concept, used in conjunction with the best existing technology, enabled the creation of 15–20 energy solutions to five architect scenarios in a two-day knotworking workshop. Cost analyses were also provided for selected energy solutions in the workshop.

The purpose of knotworking is to address the problems caused by the fragmentation of design and construction work in a multi-project environment. The fragmentation arises from the spatially and temporally distributed character of the industry, with actors from different organizations working together in an adversarial context (Bresnen and Marshall 2000). The fragmentation of the industry is deeply rooted in professional practices and bodies of knowledge (Choccio et al. 2011; Dossick and Neff 2010). Practitioners are continuously balancing between the overall project goals in temporary teams and their obligations to their company goals and contracts and their pursuit of financial success (Dossick and Neff 2011). The implications of fragmentation manifest as quality problems, time and cost overruns, and extensive uses of resources to improve the defects resulting from poor performance (Baiden et al. 2006; Choccio et al. 2011).

The implementation of building information modeling (BIM) is expected to improve the collaboration in project teams (e.g., Eastman et al. 2011). Some studies show, however, that the problems of working together in design and construction teams have not decreased with the adoption of BIM (Volk et al. 2014). Fragmentation is still one of the main obstacles in the industry that has to be solved locally in each building project. Although BIM technologies enable tighter links between project participants, they remain organizationally divided (Dossick and Neff 2010).

The uses of different team integration mechanisms are also attempts to decrease the effects of fragmentation in design and construction teams. Construction project teams exist within their organizationally defined boundaries, and the degree of their integration varies according to the adopted team practices and procurement approaches (Baiden et al. 2006). Our aim is to explore how the fragmentation of design and construction work could be diminished through knotworking in temporary and multi-disciplinary teams. An experiment in knotworking in the early design of a public school is provided as an example. Firstly, we examine the challenges and gaps connected to the fragmentation of work in the previous literature of temporary teams. Secondly, we introduce knotworking by presenting its activity-theoretically based principles (Engeström 2008). Thirdly, we describe the methodology, the methods and the data of the study. Next, we provide our findings. After that, we discuss the advantages and challenges of knotworking on the basis of our findings, and finally, we make some conclusions on the possibilities of decreasing the fragmentation of work through knotworking in multi-disciplinary design and construction teams.

## **2. The challenges and gaps identified in the previous literature on temporary teams**

Temporary teams function under constraints of high uncertainty and interdependence during a limited time. The functionality of the teams is dependent on their members’ sets of diverse skills and knowledge sets. Goodman and Goodman (1976, 494) define temporary teams as constituted of “a set of diversely skilled people working together on a complex task over a limited period of time.” Temporary teams are not separated from their contexts but function in their firm- and industry-based environments.

Gaps in the previous literature on temporary organizations and teams include the effects of the limited time of their existence, the functioning of the teams, the nature of the tasks and the characteristics of the contexts under which the teams are operating (Bakker 2010). The effects of limitations on time concern the processes, functioning, behavior and performance of temporary teams. Temporary teams are oriented by the demands of a situation, and

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