Some (Team) Assembly Required:
An Analysis of Collaborative Computer-Aided Design Assembly

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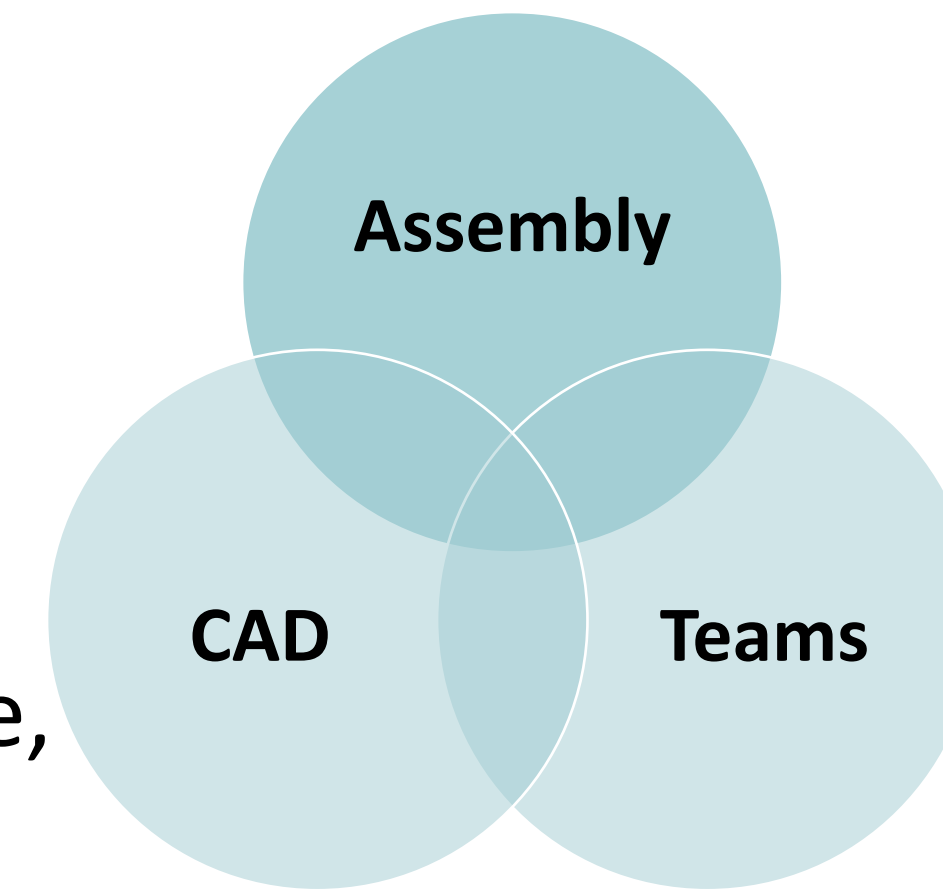
Introduction and Background

Assembly
- The addition or joining of parts to form a product
- CAD assembly is a model composed of components and/or subassemblies connected by mates

Collaborative CAD (Cloud CAD)
- Allows a group of designers to simultaneously create, manipulate, and contribute to the same CAD file
- Enhances team communication, facilitates collaboration in geographically-dispersed teams, increases awareness of and care for other team members, and increases learning opportunities

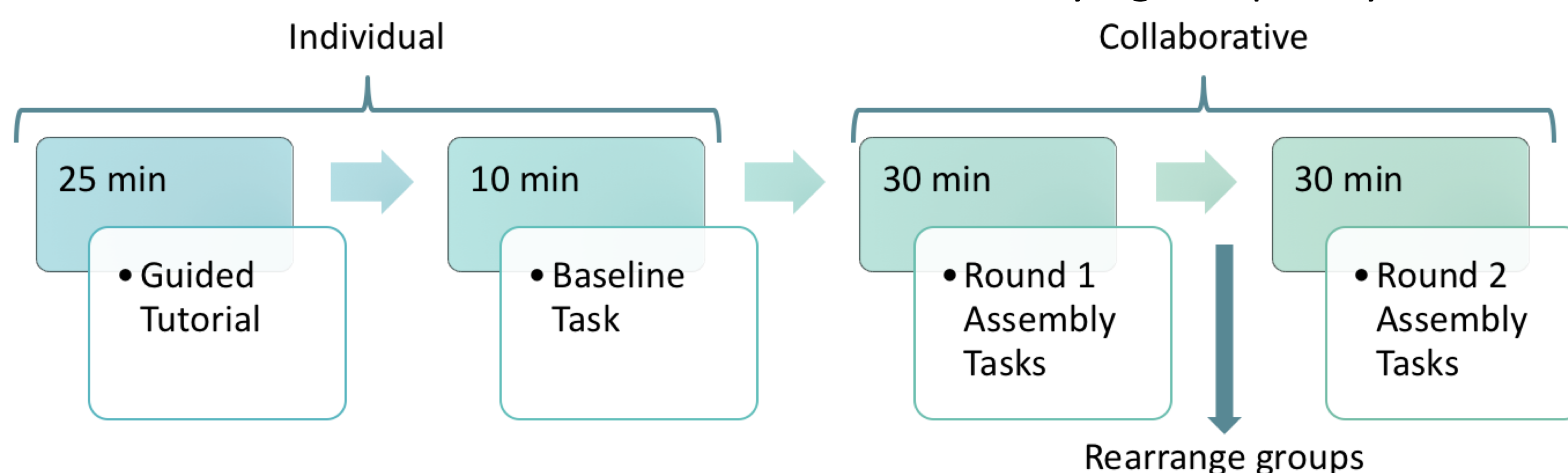→ **We propose that cloud CAD can optimize the team assembly process.**

Objectives

1. Determine whether teams demonstrate increased **productivity** versus one person working with the same collaborative CAD platform (Onshape).
2. Compare and contrast **workflow** and task allocation of high performing and low performing teams.
3. Analyze **communication** patterns of high performing teams compared with low performing teams.
4. Identify common **challenges** with team assemblies. Provide **recommendations** for CAD systems to assist collaborative assembly.

Experimental Methods

1. Initial Survey → **2. CAD Assembly Tasks** → **3. Final Survey**

- Participants: 20 undergraduate engineering students with CAD experience
- Experiment was conducted virtually on Zoom
- Teams of 1-4 added mates to 3 assemblies of varying complexity in 30 min

Individual | Collaborative

- 25 min — • Guided Tutorial
- 10 min — • Baseline Task
- 30 min — • Round 1 Assembly Tasks
- 30 min — • Round 2 Assembly Tasks

Rearrange groups

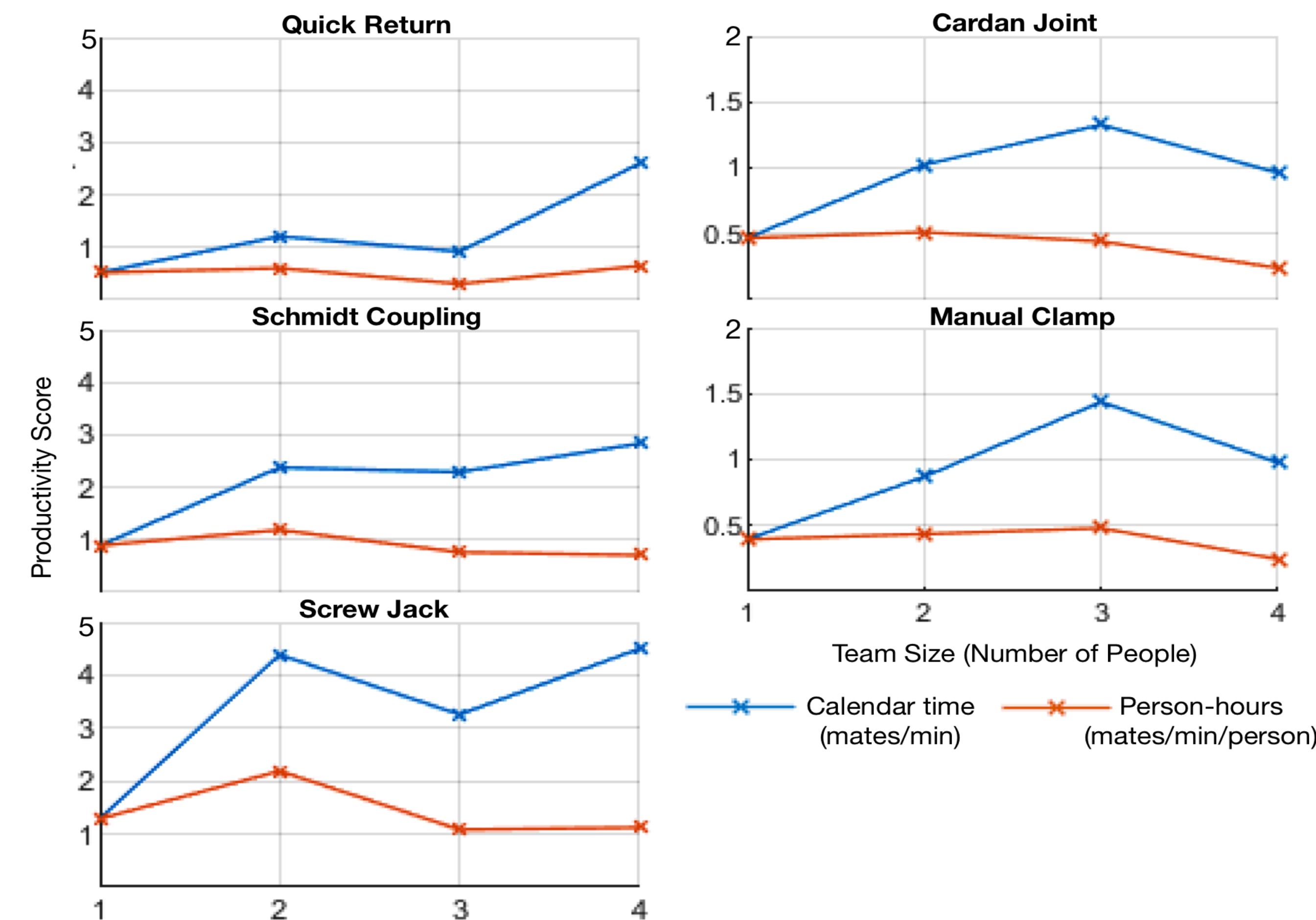## Team Size, Productivity and Workflow

Figure 1. Average productivity score of Round 1 assemblies (left) and Round 2 assemblies (right) from least complex (top) to most complex (bottom).
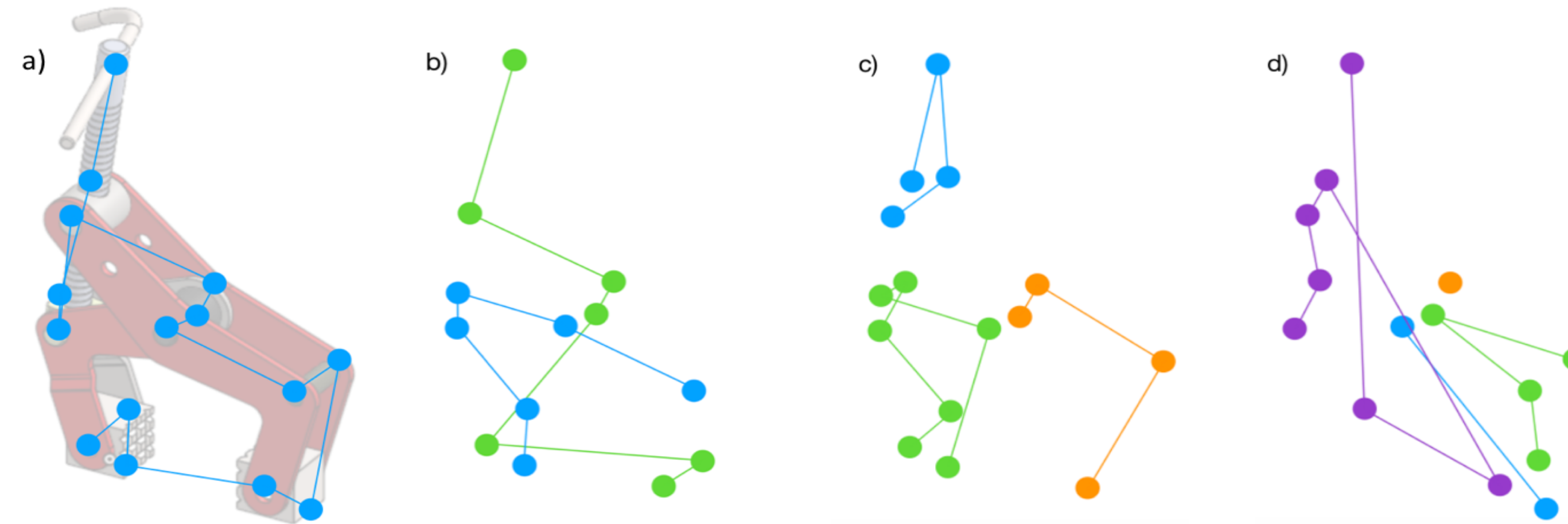
Legend:
— Calendar time (mates/min)
— Person-hours (mates/min/person)

Figure 2. Network diagrams of Manual Clamp assembly modularity of (a) single user, (b) 2-person team, (c) 3-person team, and (d) 4-person team.
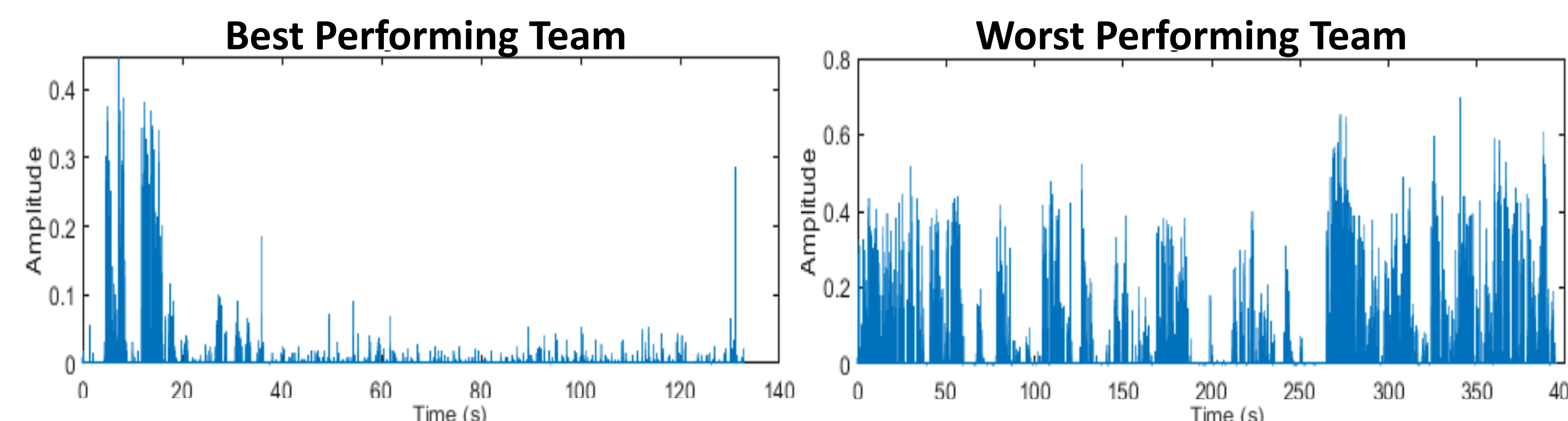
Communication and Team Performance

Figure 3. Communication frequency of best (left) and worst (right) performing team.

Challenges and Recommendations

1. Implement additional collaboration features
2. Change transparency of first selected part
— **For cloud CAD platforms**

3. Give each part in the assembly a unique identifier
4. Modularize and use subassemblies
5. Build team with diverse CAD skill levels
— **For collaborative CAD teams**

Key Findings

Collaborative assembly activities can improve the capabilities of modern product design teams, to ultimately deliver products faster and at lower cost.

Productivity
- Teams are faster than individuals at assembly in calendar time
- Individuals are more efficient than teams in terms of person hours
- Pairs are superior and exhibited "assembly bonus effect"

Workflow
- Good teams modularized assemblies and avoided overlapping workflow
- Poor teams overlapped workflow which resulted in duplicate work

Communication
- Good teams communicated selectively to plan work and share progress
- Poor teams communicated constantly due to poor planning and confusion

Challenges & Recommendations
- Collaborative CAD platforms can implement more collaboration features
- Collaborative CAD teams should have a thorough initial plan

Future Work

- Wider range of team sizes and CAD skill levels
- Greater variability of assembly complexity
- Additional metrics for team performance
- Different assembly activities