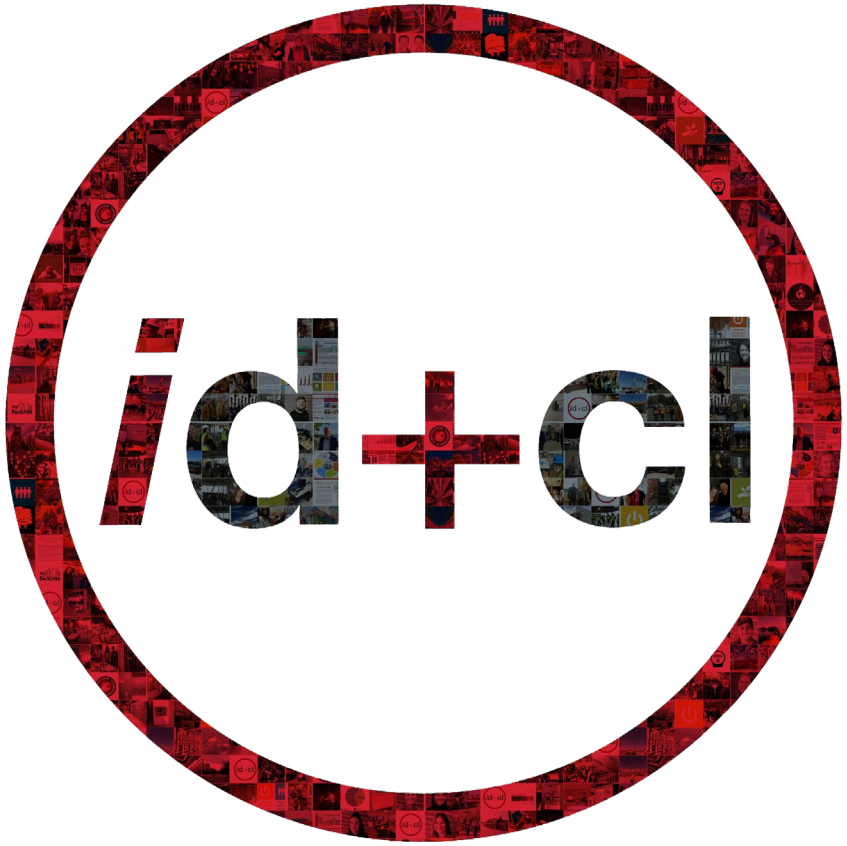


The Integrated Design + Construction Laboratory

at Washington State University

Dr. Julia K. Day & Shelby Ruiz

Introductions

ABOUT THE IDL NETWORK & ID+CL

About the Integrated Design Laboratories

About the Integrated Design + Construction Laboratory

The ID+CL seeks to transform design, construction and building operational practices to **advance high-performance buildings** that are more comfortable for people, **require less carbon** and **energy** to construct and maintain, and enhance the **health and productivity of occupants**.

Research topics include but are not limited to occupant comfort (thermal and visual), adaptive behaviors, energy efficiency, high-performance buildings, human-building interfaces and controls, and management of human satisfaction and behaviors.

After this project, we can add two more areas of expertise to our repertoire! Industrialized construction and workforce development. More info coming soon!

HEALTHY PEOPLE + HEALTHY BUILDINGS + A HEALTHY PLANET

Introductions

MEET OUR TEAM!

Meet the ID+CL Team (2024)

Dr. Julia Day

Associate Prof.

Director, ID+CL

Zach Colligan

Sierra Wilson

Jacob Roibal

Shelby Ruiz

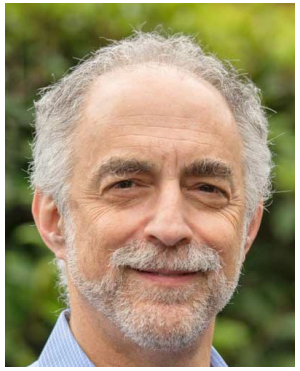
Research Associate

Nick Mayer

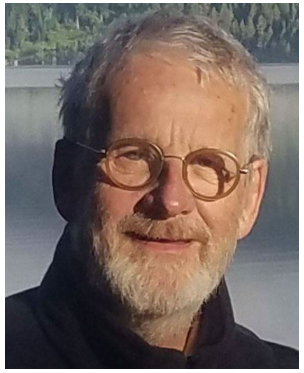
Ethan Baum

Sarah Truitt
NREL
Innovation Area Lead for Workforce

Julia Sullivan
NREL
Sustainable Buildings Researcher



Adam Parker
RMI
REALIZE Market Consultant



Dr. Peter Philips,
University of Utah
Labor Economist and Professor

Dr. Kevin Duncan,
Colorado State University
Pueblo,
Professor of Economics

Dodge Construction Network

The rest of the research team!

Photograph Sources: Sarah Truitt (left) and Julia Sullivan (second from left)- Source: NREL
Adam Parker (center) Source: RMI https://rmi.org/people/adam-parker/
Peter Philips (second from right) Source: University of Utah https://faculty.utah.edu/u0035312-PETER_W_PHILIPS,_Labor_Economist/hm/index.hml;jsessionid=3A1022FDA9E508DD84D056F91AFC6F9A
Kevin Duncan (right) Source: CSU Pueblo https://www.csupueblo.edu/profile/kevin-duncan/index.html
Dodge Construction Network logo: https://www.construction.com/news/Introducing-Dodge-Construction-Network

Presentation Agenda

Introductions

About Industrialized Construction (IC)

About the IC project

Methodology

- Survey
- Interviews

Results

Discussion and Conclusions

Questions

Background and Definitions

WHAT IS INDUSTRIALIZED CONSTRUCTION?

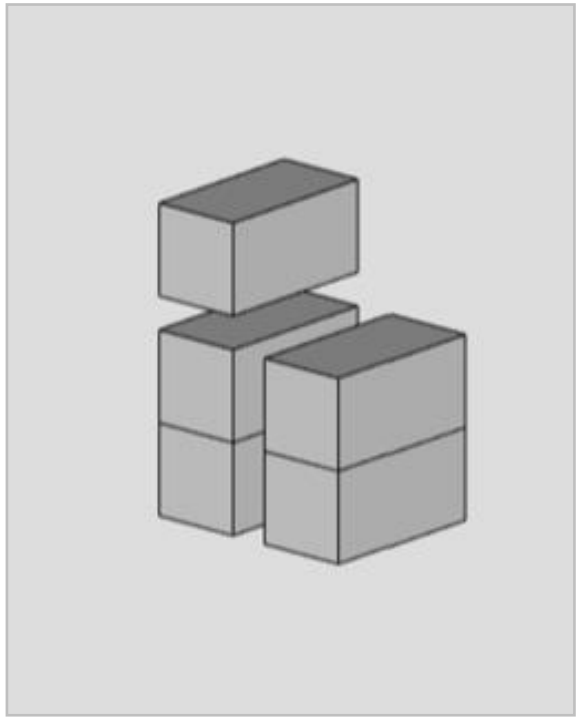
What is Industrialized Construction?

Industrialized Construction (IC) uses industrial, manufacturing-based principles and production methods such as advancements in computing, automation, construction planning and management, and materials science for greater productivity. These principles can be applied to onsite and/or offsite construction conditions. (defined by HUD)

Potential benefits of industrialized construction include improved quality control, reduced on-site construction schedule, and may help reduce labor/workforce constraints that are currently a challenge in the industry.

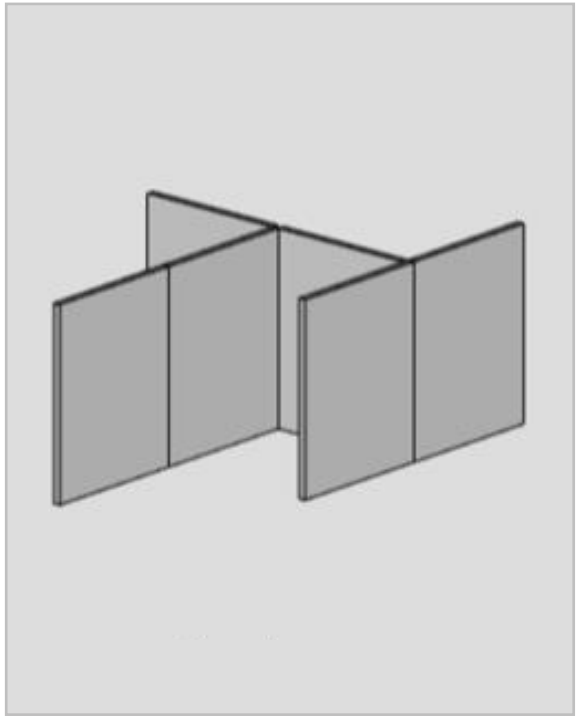
Image Source: Lucideon https://www.lucideon.com/construction/offsite-modular-buildings

Definitions + Examples



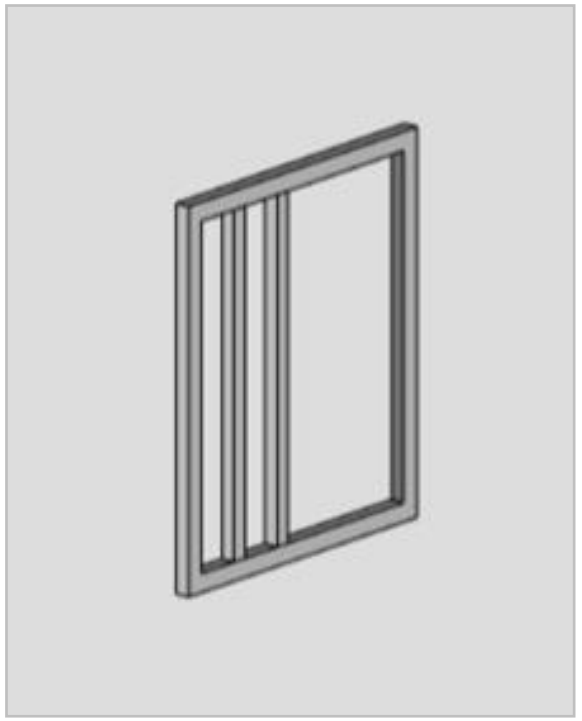
Volumetric Modular

3-D off-site-built “blocks”/pods that are connected and tied together on site, often inspected off-site



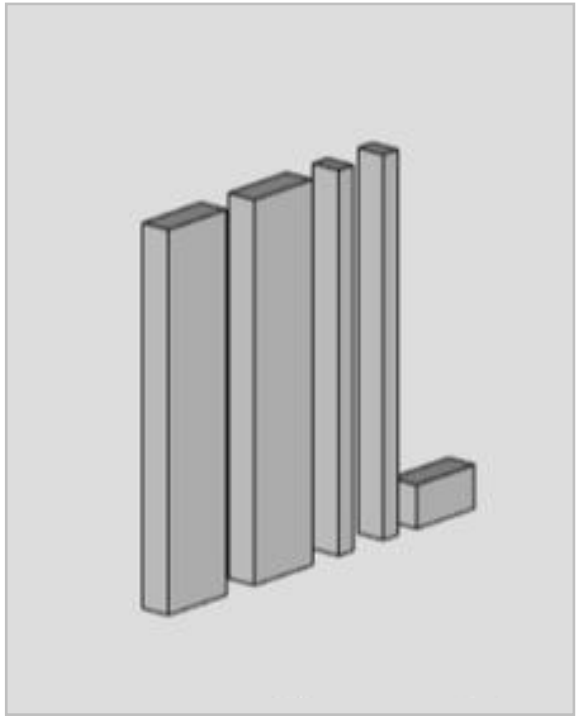
Panelized Modular

Like volumetric, but panels or smaller sub-set assemblies instead of whole unit “blocks”, fabricated off-site; assembled on-site



Pre-Fab. Components

Often MEP components that are framed, partially assembled, or kitted for installation



Mass Timber

Engineered composite wood products (e.g., pillars, beams, joists, etc.) that can be used in place of structural steel or concrete

Image source: Garrison & Tweedie, 2008

Definitions + Examples

Guerdon Modular Buildings, 2017

Volumetric Modular

WSU Courtyard by Marriott Hotel (114 modular units)
Pullman, WA


DIRTT , 2017

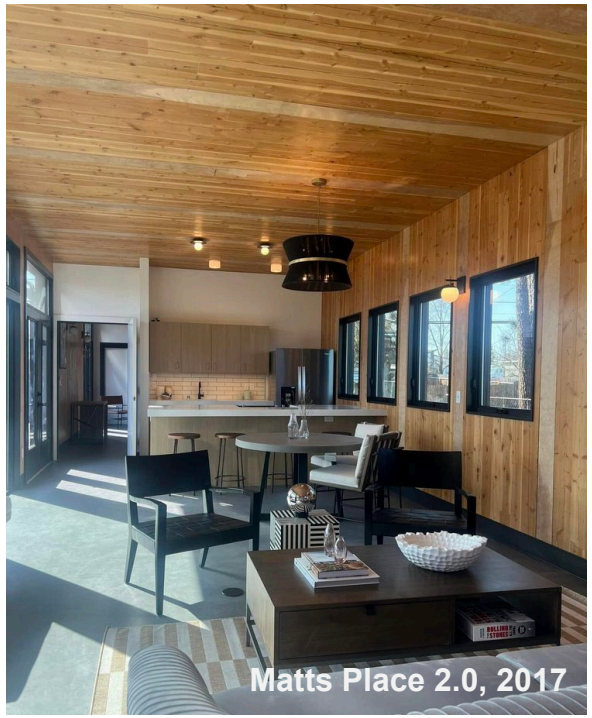
Panelized Modular

Modular multi-trade healthcare headwall example


McKinstry, 2017

Pre-Fab. Components

Multi-Trade racks example


Matts Place 2.0, 2017

Mass Timber

Matt's Place Foundation home 2.0 (panelized MT)
Spokane, WA

CARBON + ENERGY

SO, WHAT? HOW DOES THIS MATTER?

Potential benefits of IC

- Reduces the cost of construction *(it can, but not always!)*
- Reduces construction delivery time
- Creates potential to deliver affordable buildings at scale
- Enables more building decarbonization *(carbon sequestering through materials also potential benefit)*
- Allows more building electrification
- Provides grid friendliness
- Improves resilience

JUMP into STEM intern Samantha Eddy has been working with her mentors, including research engineer, Ankur Podder, within the Building Technologies and Science Center with the Industrialized Construction Innovation (ICI) team to support passive and active design strategies for energy-efficient modular housing, at the National Renewable Energy Laboratory (NREL). (Photo by Werner Slocum / NREL)

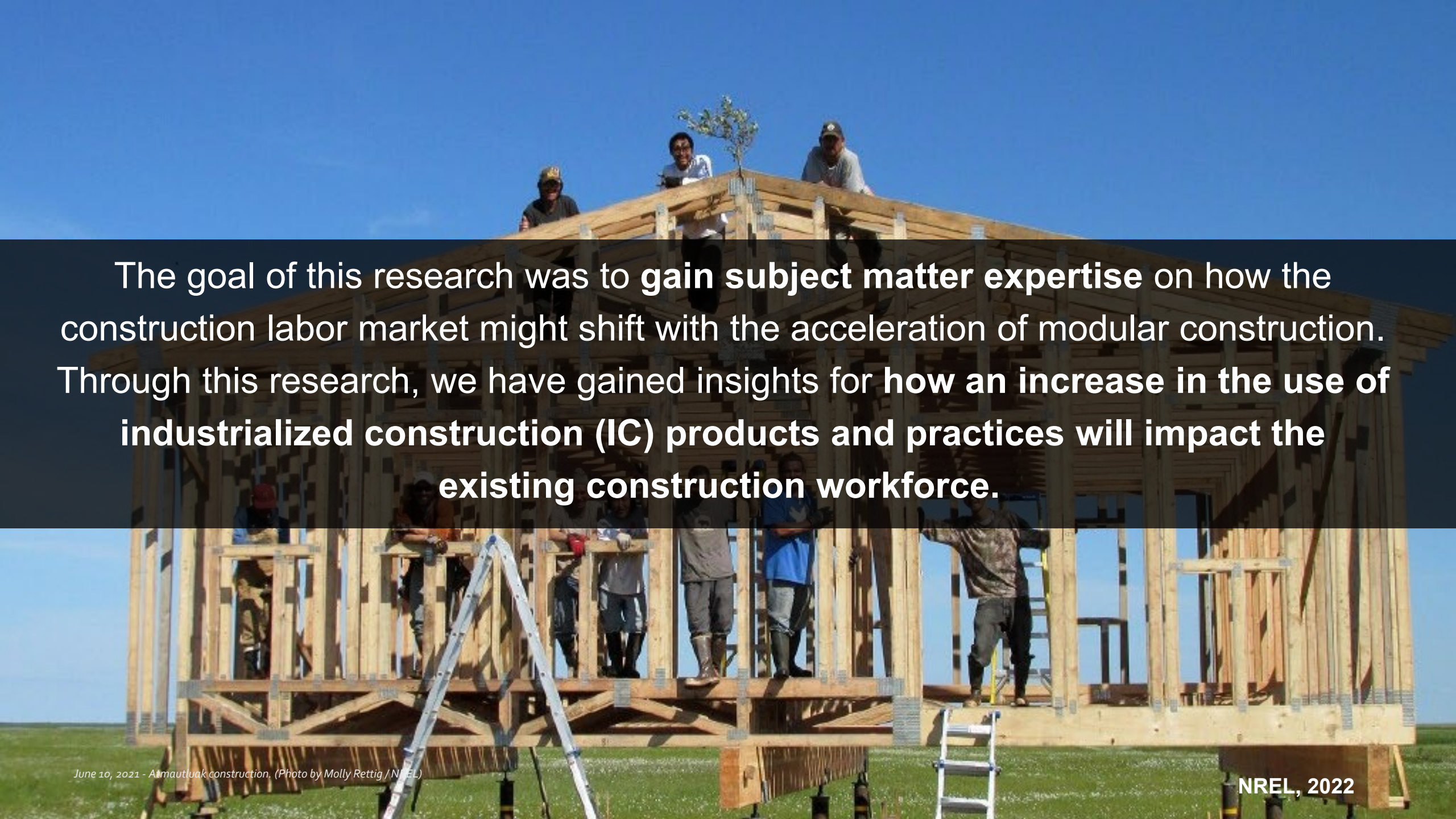
Additional potential benefits of IC

- Sustainability benefits – waste reduction, more efficient manufacturing
- Possible integration of high efficiency products in mass with adoption of IC
- Affordable housing and multifamily impacts – e.g., pumps, WHs
- Human benefits – potential improvements in workplace conditions, career opportunities, diversity + equity opportunities
- Overall – Can help to address labor shortages in the construction industry, housing/development needs, overall buildability

NREL IC Project Details

INDUSTRIALIZED CONSTRUCTION OVERVIEW

Purpose, Goals, and Research Questions



The goal of this research was to **gain subject matter expertise** on how the construction labor market might shift with the acceleration of modular construction. Through this research, we have gained insights for **how an increase in the use of industrialized construction (IC) products and practices will impact the existing construction workforce.**

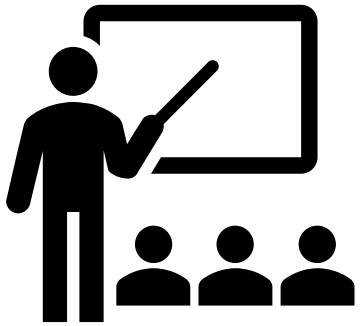
June 10, 2021 - Atmautluak construction. (Photo by Molly Rettig / NREL)

NREL, 2022

Goals of this Research

Discover whether benefits of IC are being realized in the field, identify what is working/what's not, what's being adopted/what's not and why

Characterize job roles, skills, wages and working conditions of IC jobs in specific IC categories



Understand challenges and training gaps, by product category

Guiding Research Questions

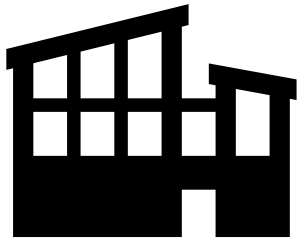
Topic	Research Questions
Industry Workforce Changes	Where are the opportunities for new skills, job categories or occupations, in what IC scenarios?
	Where are the dislocations (i.e., what job categories will be displaced), in what scenarios?
Training and Engagement	What training exists, and what needs to be put in place?
	How can we best prepare the workforce to adapt to and benefit from industrialized construction?
Employee Impacts	Where are the opportunities to expand the workforce to include more diverse populations?
	How will working conditions and wages evolve under different scenarios of IC?

NREL IC Project Details

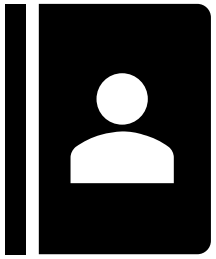
METHODOLOGY

Methodological approach

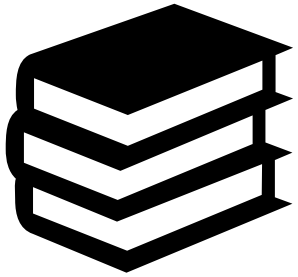
This research is a mixed methods study, which includes both qualitative and quantitative data collection. Through case studies, business profiles, literature review, in depth semi-structured interviews, and a national survey, our team has gained a multi-dimensional understanding of how industrialized construction products and practices will impact the existing construction workforce.



Project Case Studies



Company/business Profiles



Literature Review

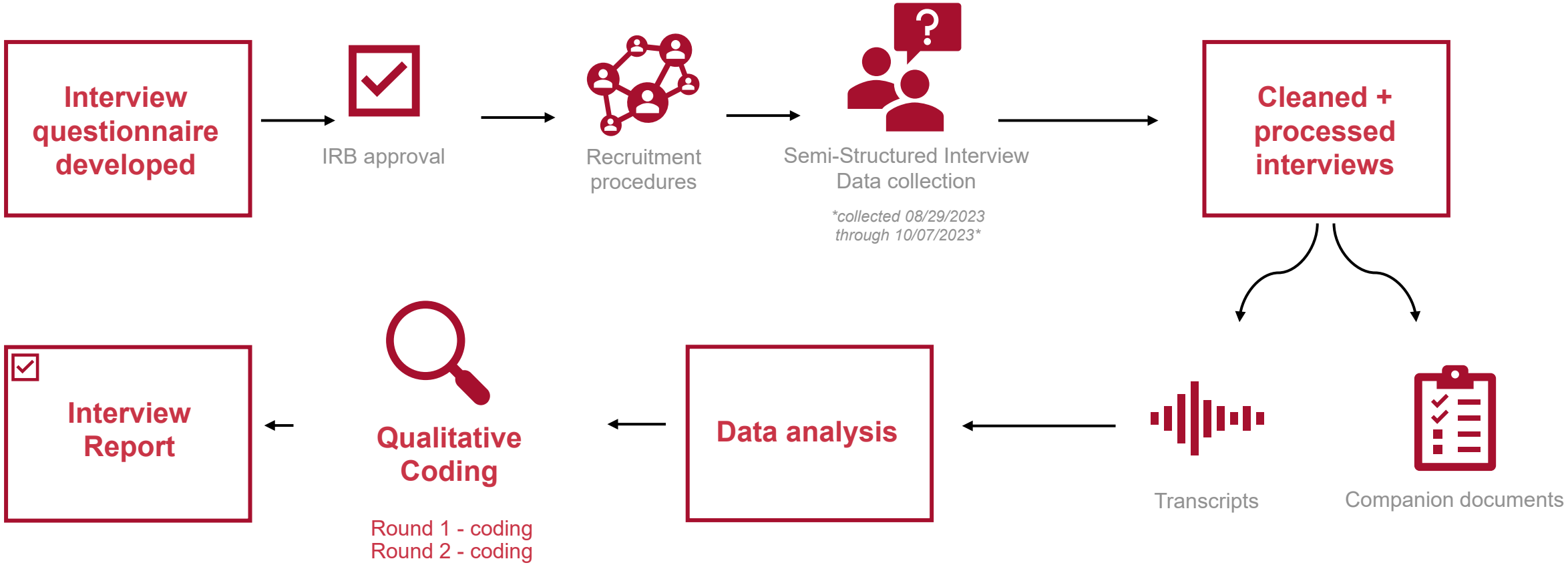
In-depth semi-structured virtual interviews ***n=30***

National Contractor and Manufacturer Survey ***n=312***

WSU ID+CL Scope of Work

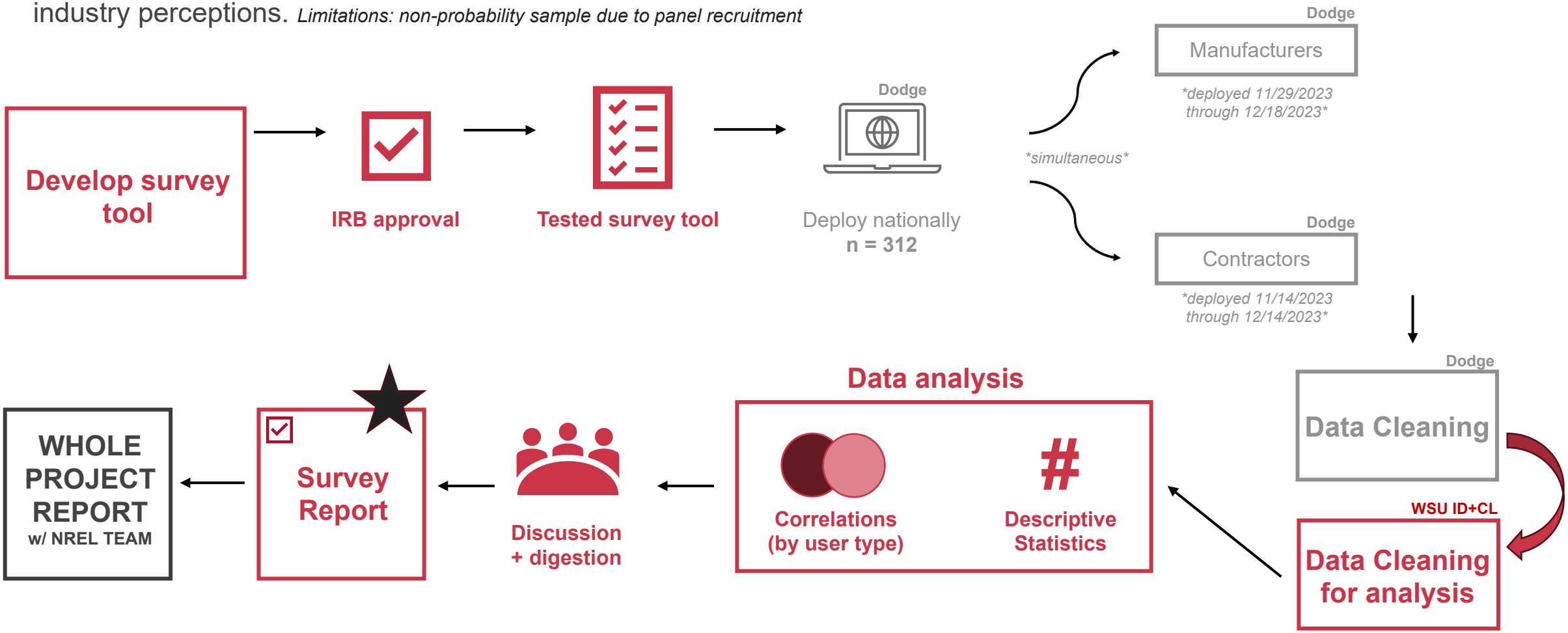
Interview Methodology

Interviewees were recruited through company searches via google, LinkedIn, referrals, personal connections, and in person recruitment at a large Modular Construction Event. Company and interview requests were selected based on IC types, region, and types of products and/or practices. After the interviews were transcribed and cleaned, the transcripts were added into the QSR NVivo 10 software for coding.



Survey Methodology

Research data were collected via two separate national survey panels. Frequency and descriptive statistics were pulled for all survey questions. User groups, delineated by participant type (construction contractors vs offsite manufacturers) were further separated from the data to determine differences in participant type and industry perceptions. *Limitations: non-probability sample due to panel recruitment*



NREL IC Project Details

PARTICIPANTS

About the interview participants

Characteristics of interview participants		
	Participant (qty.)	**Job titles**
Organized Labor and Industry Groups	3	• Director of business improvement • EPA and chief culture officer • Director of organizing
General Contractors and Subs	6	• Co-founder • Director of manufacturing • Director of preconstruction • Director of preconstruction • Project manager • Operations manager
Training Organizations and Schools	1	• Founder
Architecture / Engineering / Design	6	• Architect • Director of sustainability • Chief technical officer • Director of design • Interior designer • Architectural project manager • Director of design • Principal
Developers	3	• Director of plant operations • Founder and president • Partner and director of business development
Manufacturers	8	• Founder and CEO • Mentor • Director of manufacturing • Director of manufacturing • Director of continuous improvement • Founder, owner, and president • Director of engineering • General manager

About the survey participants

Characteristics of survey participants			
	Participant response options	**Count**	**%**
Q2: Which of the following best describes your company?	General construction / General contractor	166	53.2%
	Design-build firm	17	5.4%
	Specialty trade or MEP contractor	64	20.5%
	Manufacturer or supplier of modular or panelized construction products	59	18.9%
	On-site installation or setting contractor	6	1.9%
Q3: What parts of the value chain does your company directly serve? (Select all that apply)	Design	62	--
	Manufacturing	73	
	Transportation	28	
	Setting	60	
	Construction	268	
	Commissioning / Permitting	34	
Q4: Which of the following job functions/departments best describes your job role?	Human Resources Professional	7	2.2%
	Executive / Director	103	33%
	Supervisor/Manager, (e.g., Project Manager, Safety Manager, etc.)	148	47.4%
	Administrative Staff	19	6.1%
	Tradesperson / Laborer / Worker	12	3.8%
	Other	23	7.4%

Results and Discussion

FINDINGS BY RESEARCH QUESTION

Guiding Research Questions (reminder)

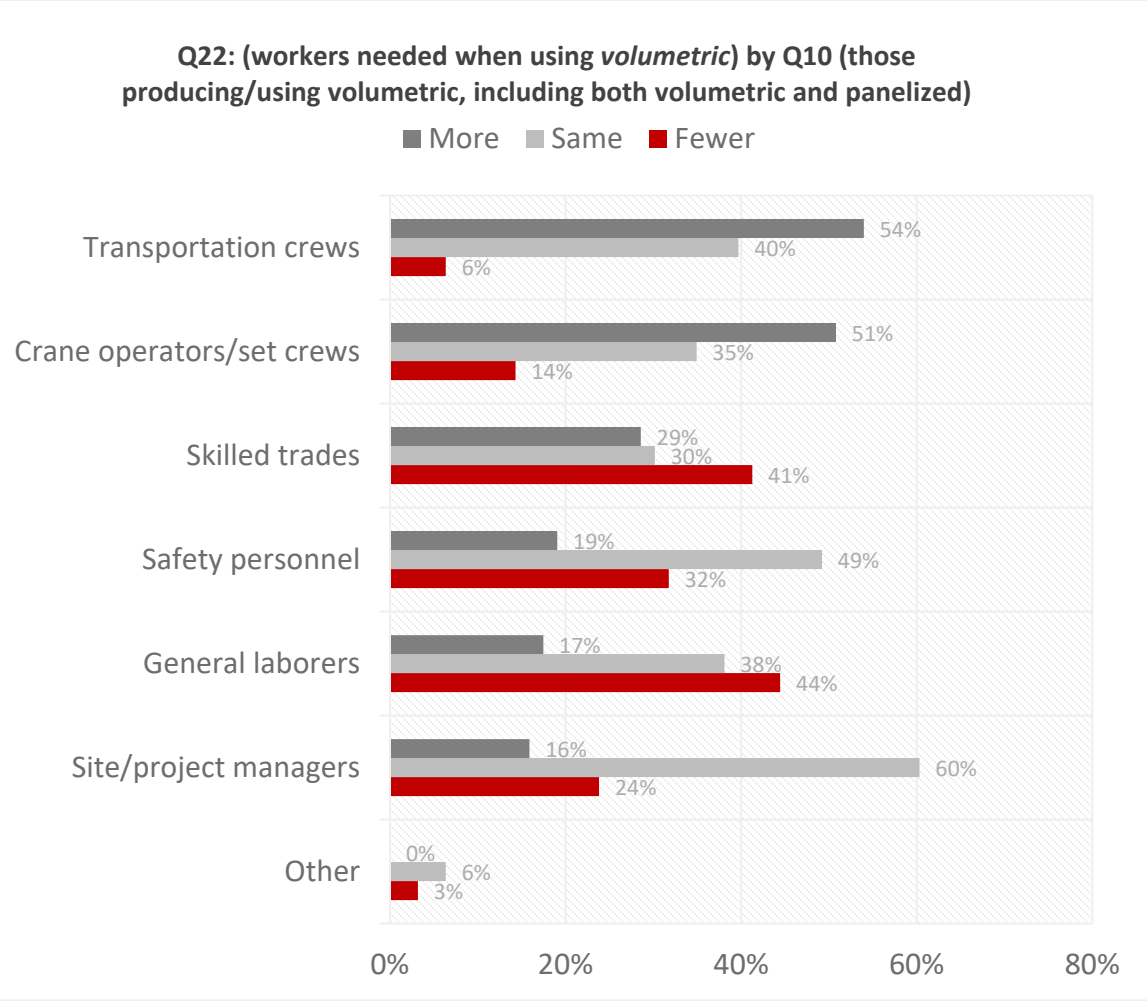
Topic	Research Questions
Industry Workforce Changes	Where are the opportunities for new skills, job categories or occupations, in what IC scenarios?
	Where are the dislocations (i.e., what job categories will be displaced), in what scenarios?
Training and Engagement	What training exists, and what needs to be put in place?
	How can we best prepare the workforce to adapt to and benefit from industrialized construction?
Employee Impacts	Where are the opportunities to expand the workforce to include more diverse populations?
	How will working conditions and wages evolve under different scenarios of IC?

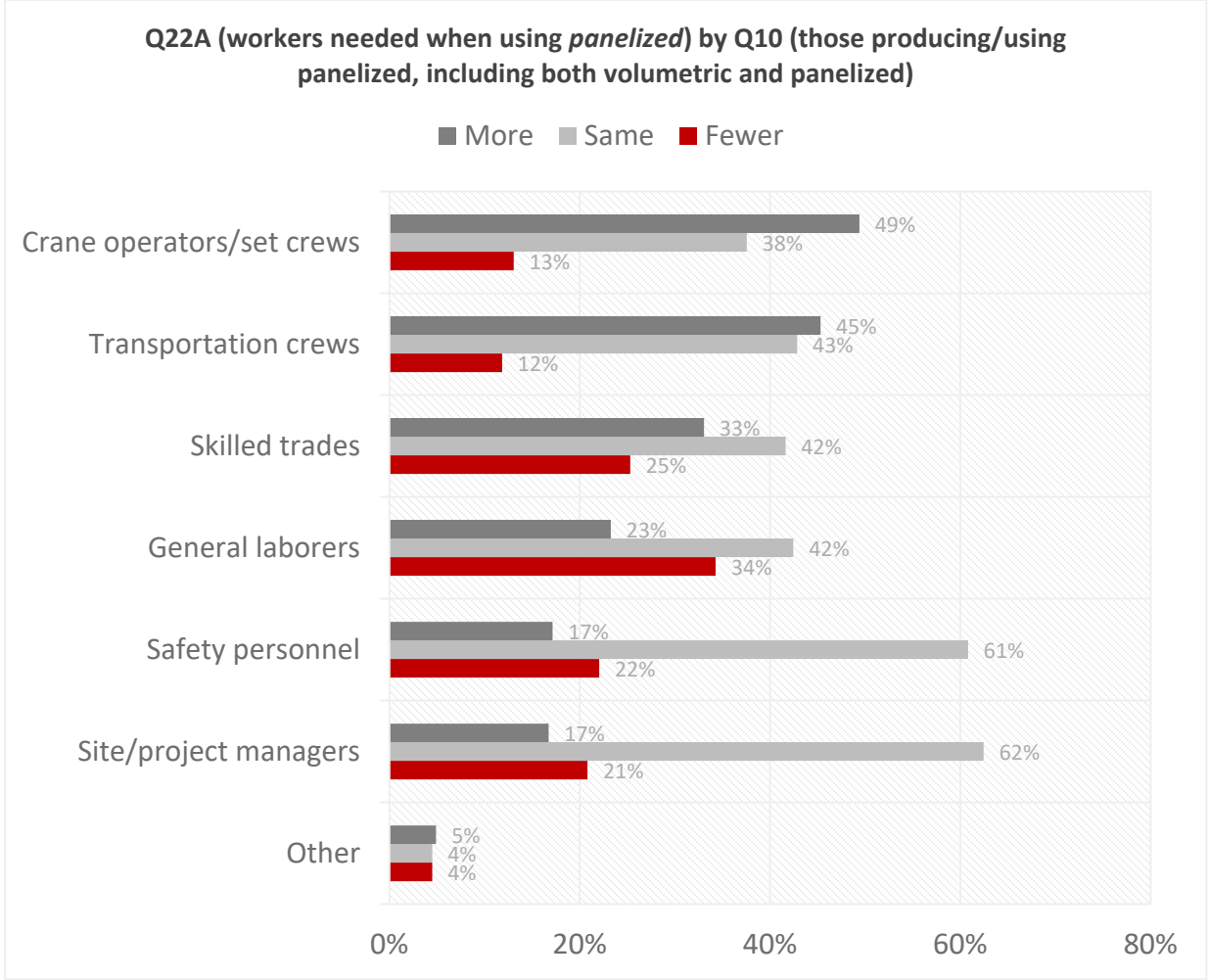
RESEARCH QUESTIONS | Industry Workforce Changes:

Where are the opportunities for new skills, job categories or occupations, in what IC scenarios?

Where are the dislocations (i.e., what job categories will be displaced), in what scenarios?

Q22 &Q22A – PLEASE INDICATE WHETHER YOU THINK FEWER OR MORE WORKERS IN EACH CATEGORY ARE NEEDED WHEN USING VOLUMETRIC/PANELIZED MODULAR CONSTRUCTION METHODS RATHER THAN TRADITIONAL CONSTRUCTION METHODS.

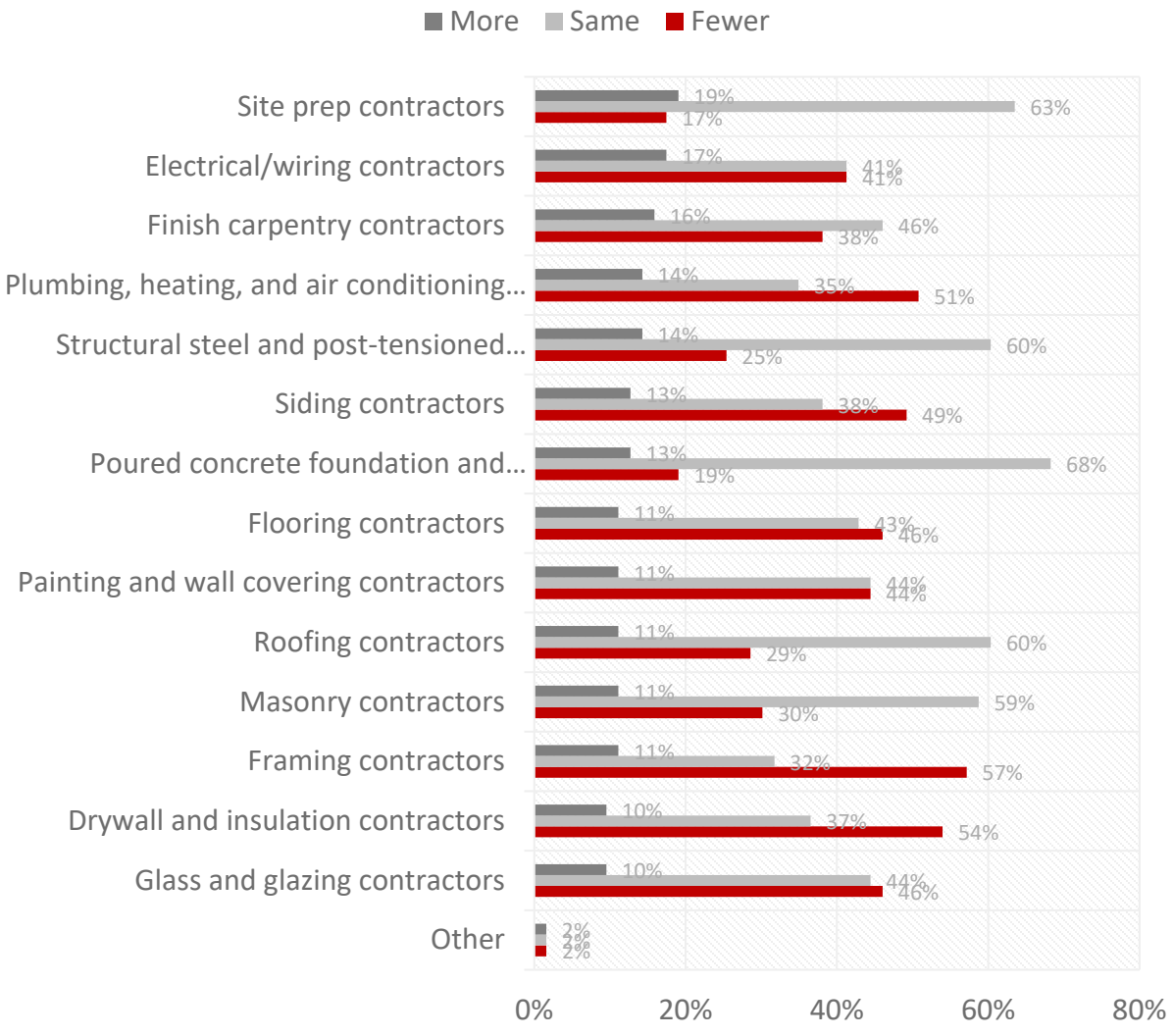




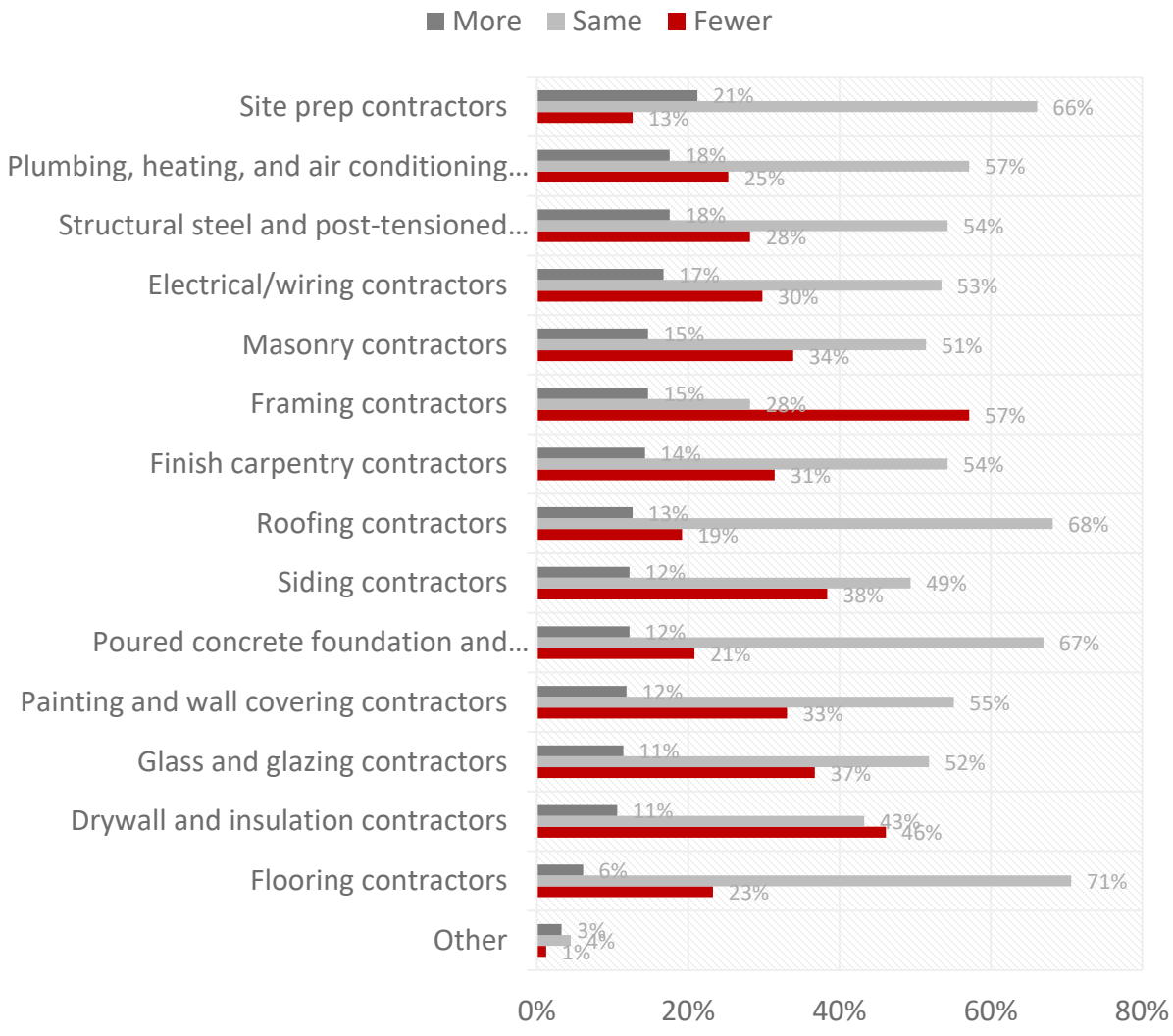
INDUSTRY WORKFORCE CHANGES

Q23 & 23A – HOW WOULD THE NUMBER OF SKILLED TRADE WORKERS CHANGE WITH THE ADOPTION OF VOLUMETRIC/PANELIZED MODULAR CONSTRUCTION?

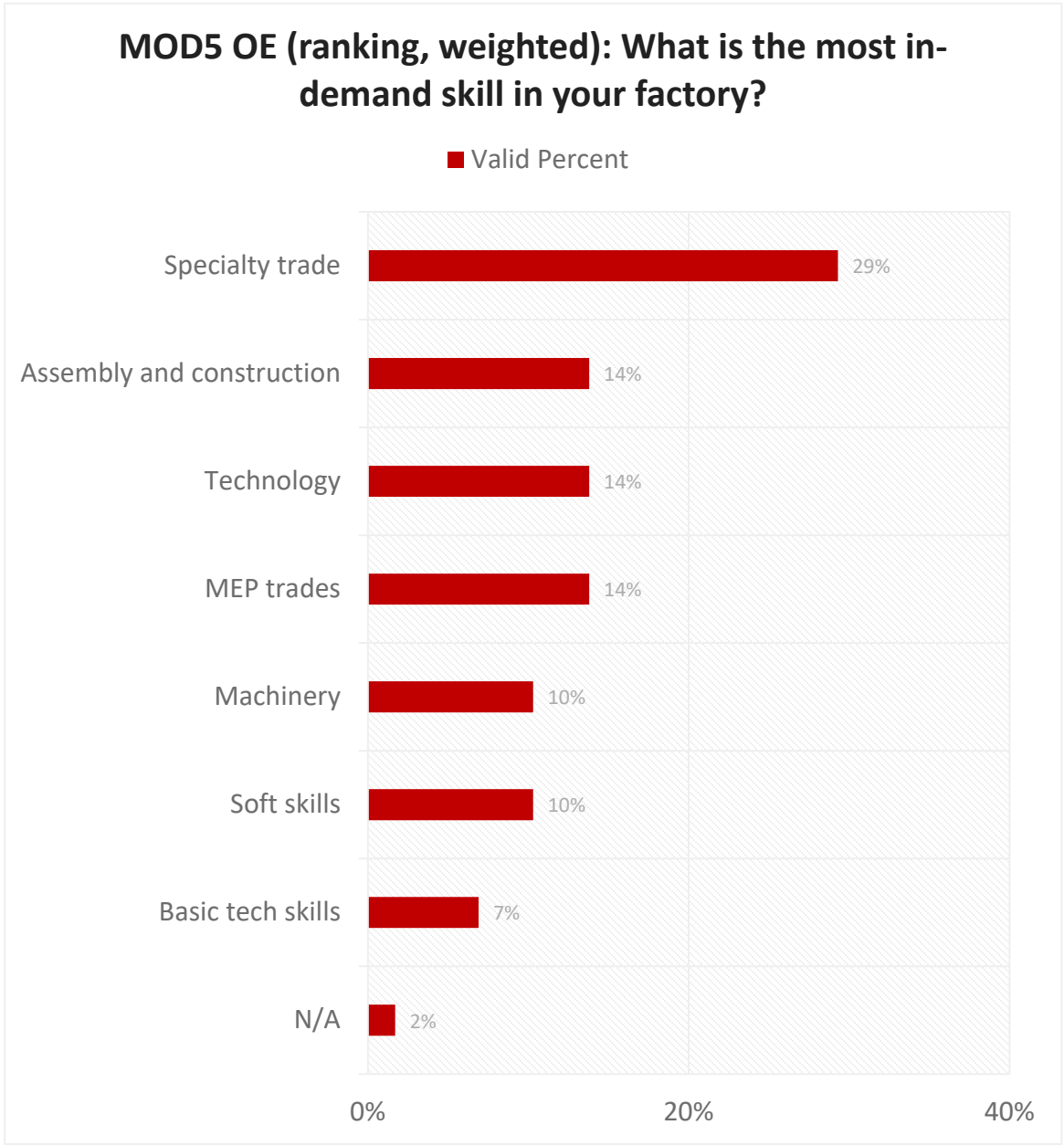
Q23 (change in skilled trade workers when using volumetric) by Q10 (those producing/using volumetric, including both volumetric and panelized)

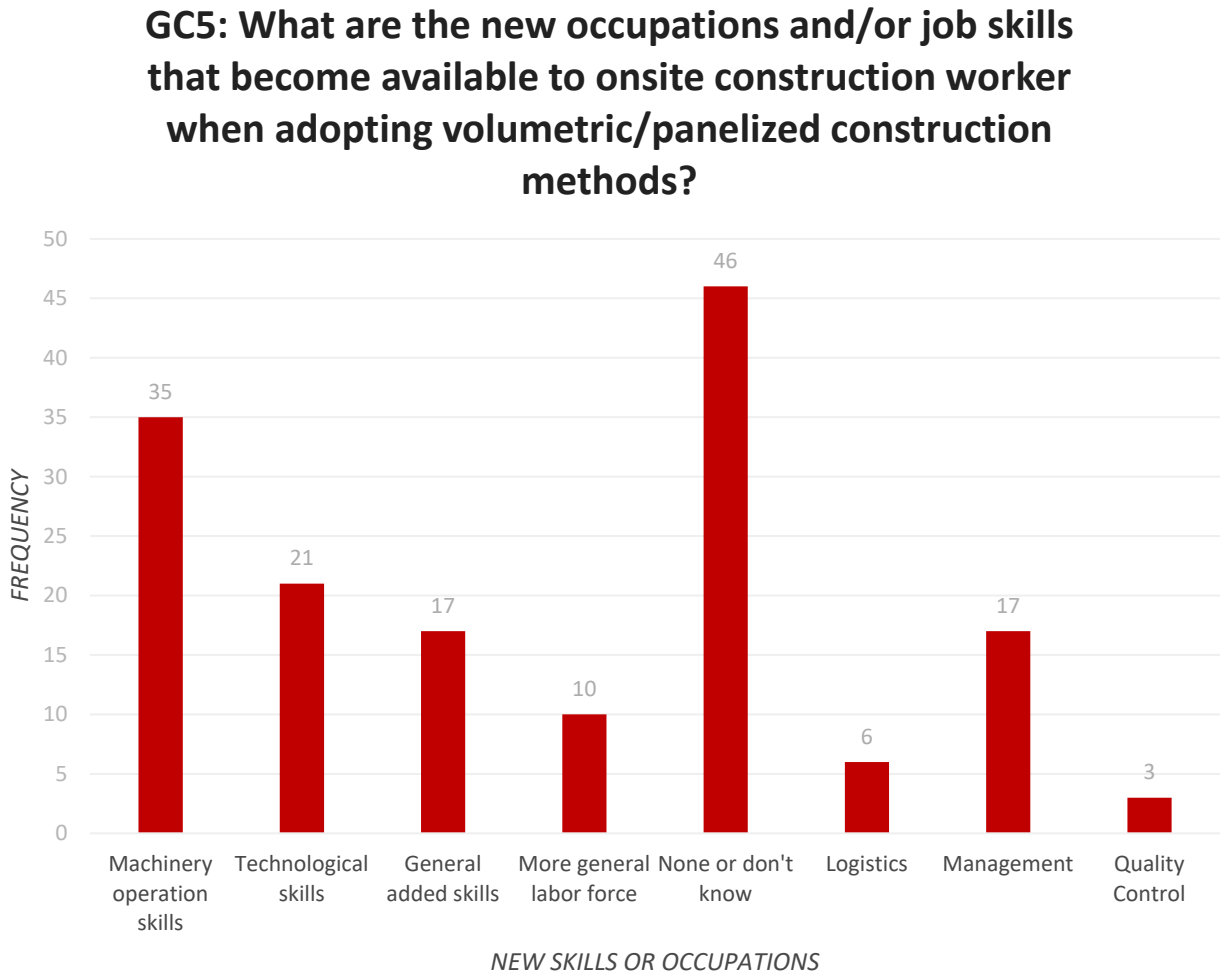


Q23A (change in skilled trade workers when using panelized) by Q10 (those producing/using panelized, including both volumetric and panelized)



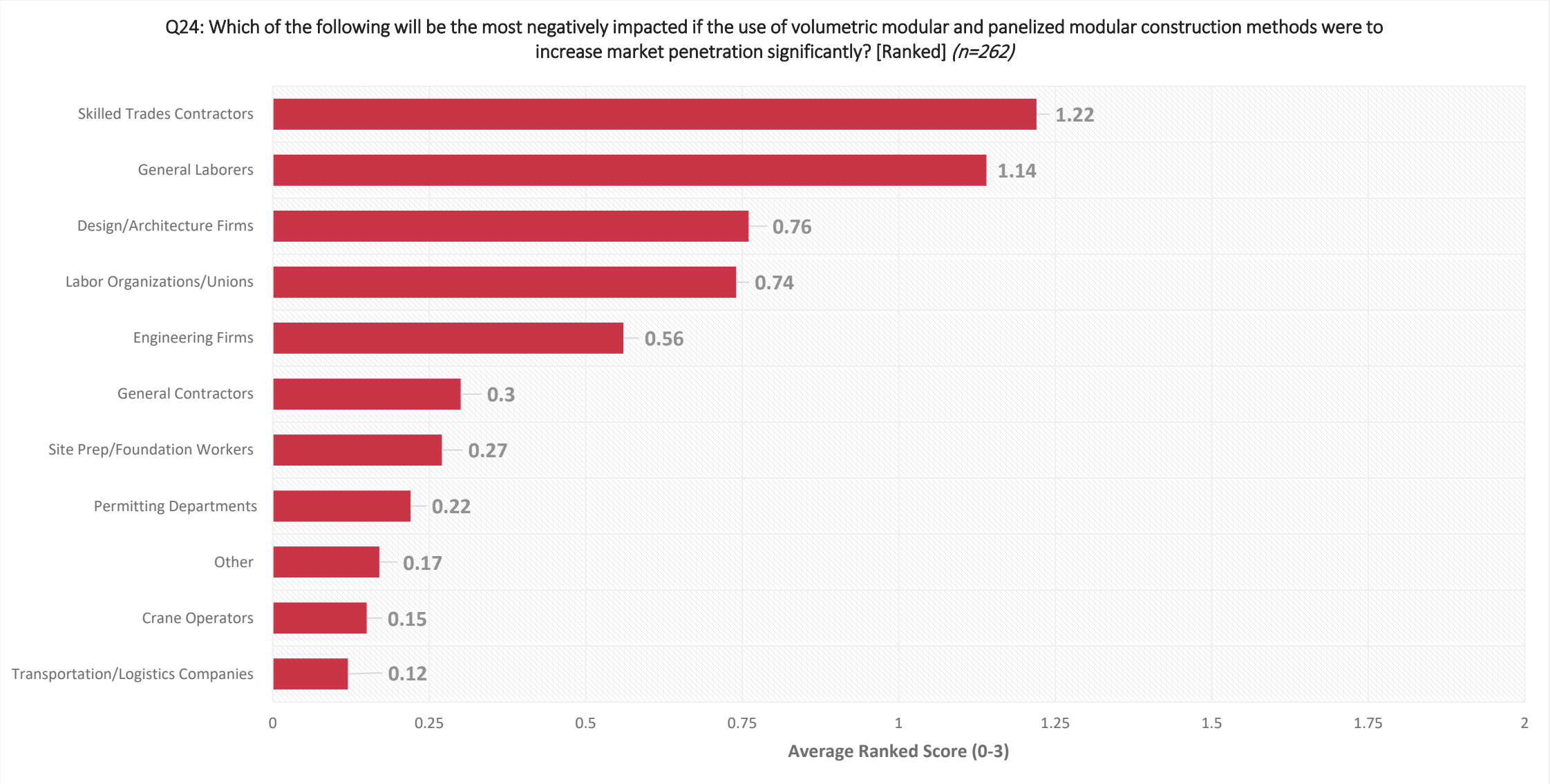
INDUSTRY WORKFORCE CHANGES





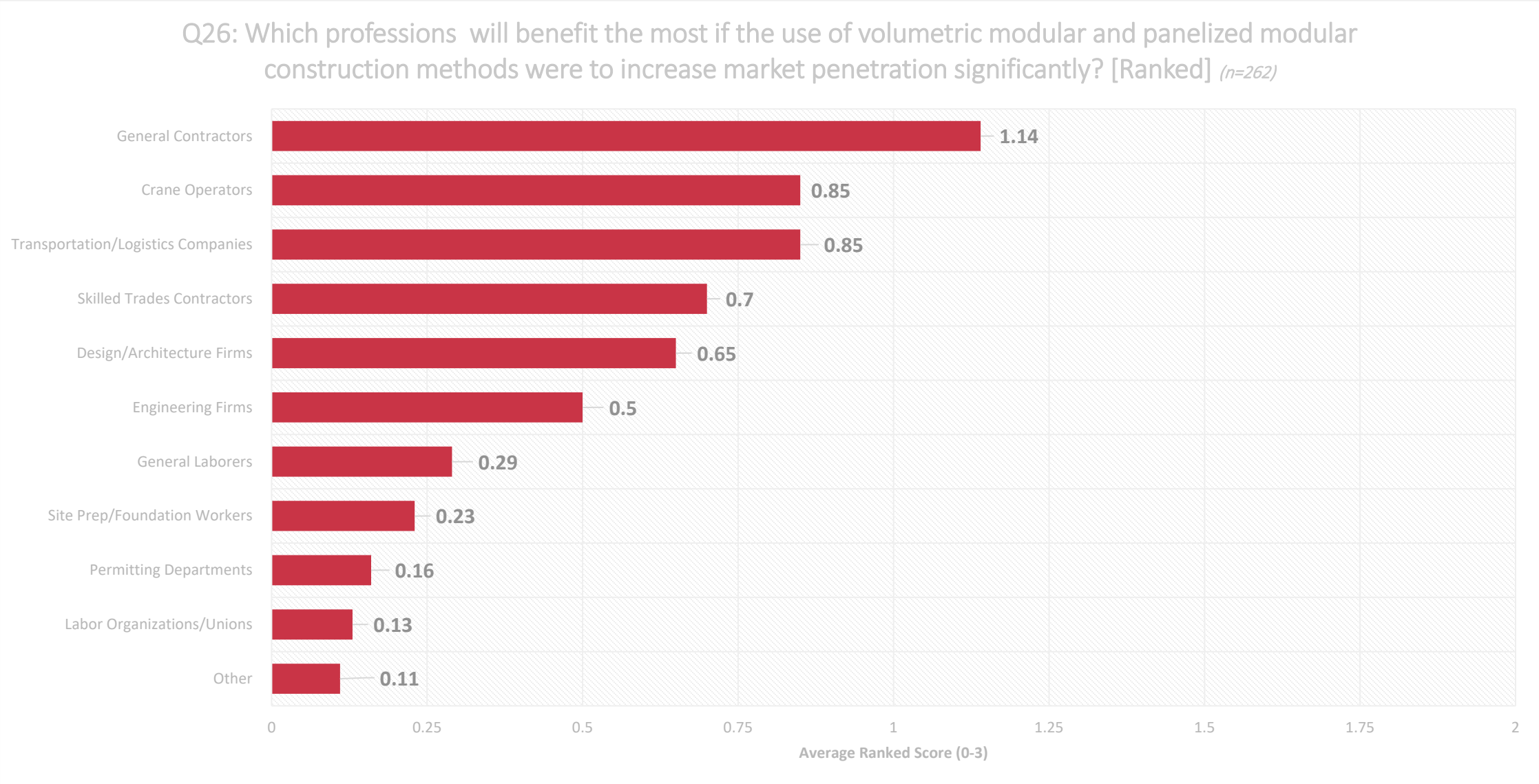
INDUSTRY WORKFORCE CHANGES

Q24 A, B, C (RANKING)– WHICH OF THE FOLLOWING WILL BE THE MOST NEGATIVELY IMPACTED IF THE USE OF VOLUMETRIC MODULAR AND PANELIZED MODULAR CONSTRUCTION METHODS WERE TO INCREASE MARKET PENETRATION SIGNIFICANTLY?



INDUSTRY WORKFORCE CHANGES

Q26 A, B, C (RANKING)– WHICH PROFESSIONS WILL BENEFIT THE MOST IF THE USE OF VOLUMETRIC MODULAR AND PANELIZED MODULAR CONSTRUCTION METHODS WERE TO INCREASE MARKET PENETRATION SIGNIFICANTLY?



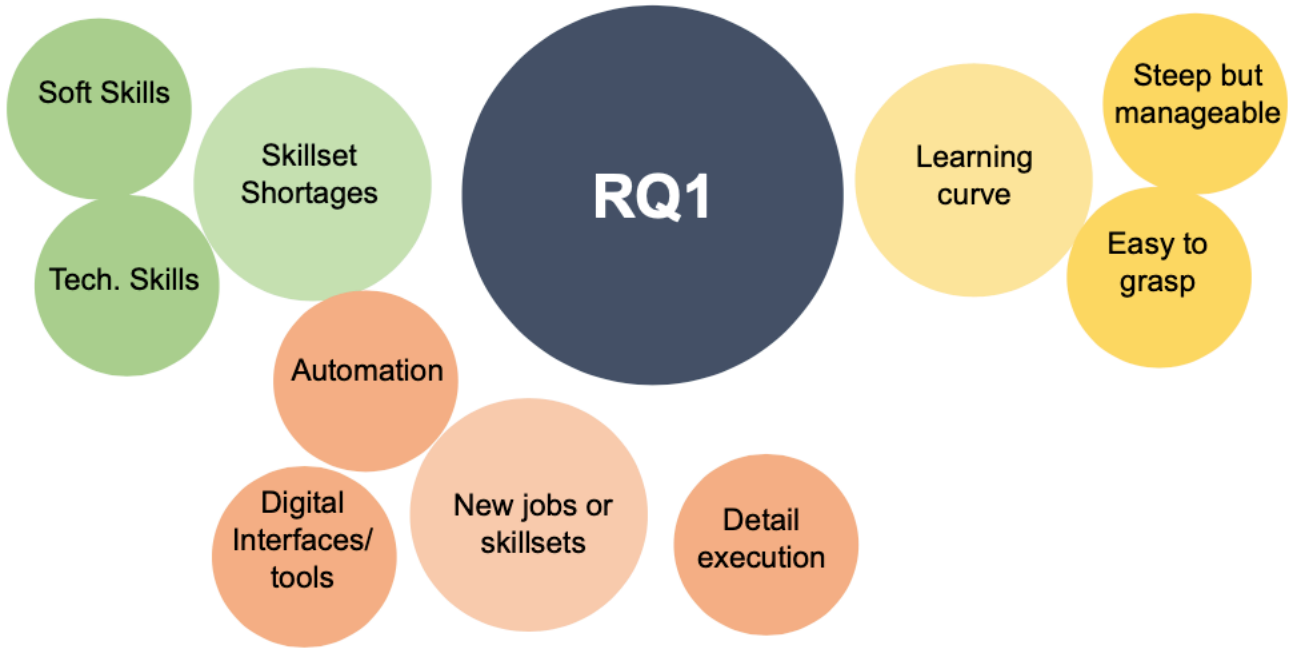
INDUSTRY WORKFORCE CHANGES

MATT'S PLACE SPOKANE

INTERVIEW DISCUSSION

INTERVIEW DISCUSSION RQ 1+2

Figure 1: The figure below documents some of the key codes and themes that emerged from RQ1.



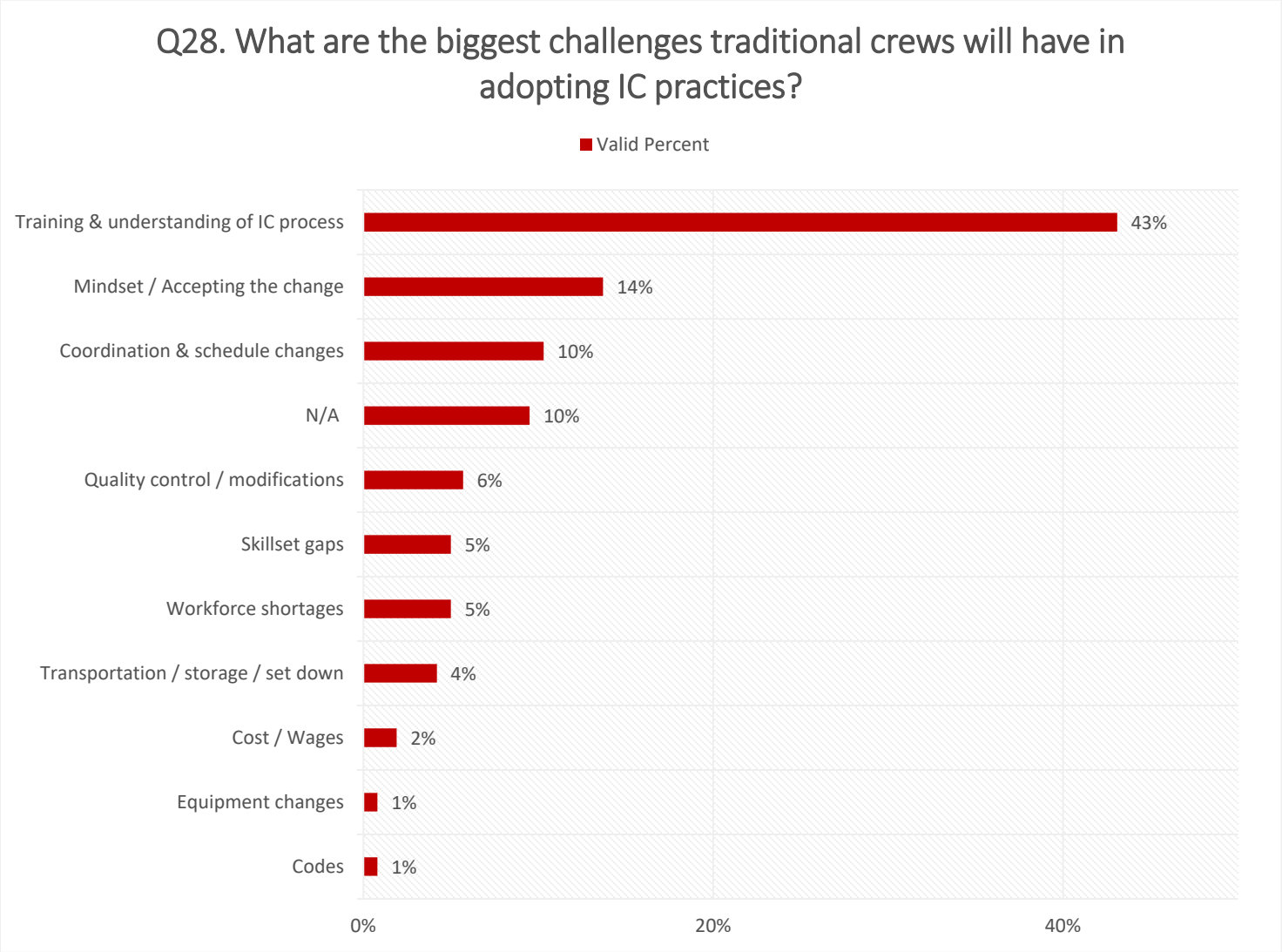
"Yeah, it's not necessarily new skills. It's more of a learning process. It's kind of like going from being a kid, going from making logs to Legos or Legos turned erector set. It's just **a better understanding of what's happening, knowing how things do for modular, how they connect, knowing the proper layout on the panels**."

*"I think when you automate something, I think the first thing that ever takes a hit is probably in **general labor because you're trying to get out generalized steps out of the process** that you know, anybody could do, right. But with that comes also specialized labor, right? So specialized fabrication. So a fabrication team would probably grow with more automation because their fabrication team would be replacing, you know. That generalized laborer who might be working in welding or fabrication one day and then framing the next day."*

RESEARCH QUESTIONS | Training + Engagement:

What training exists, and what needs to be put in place?

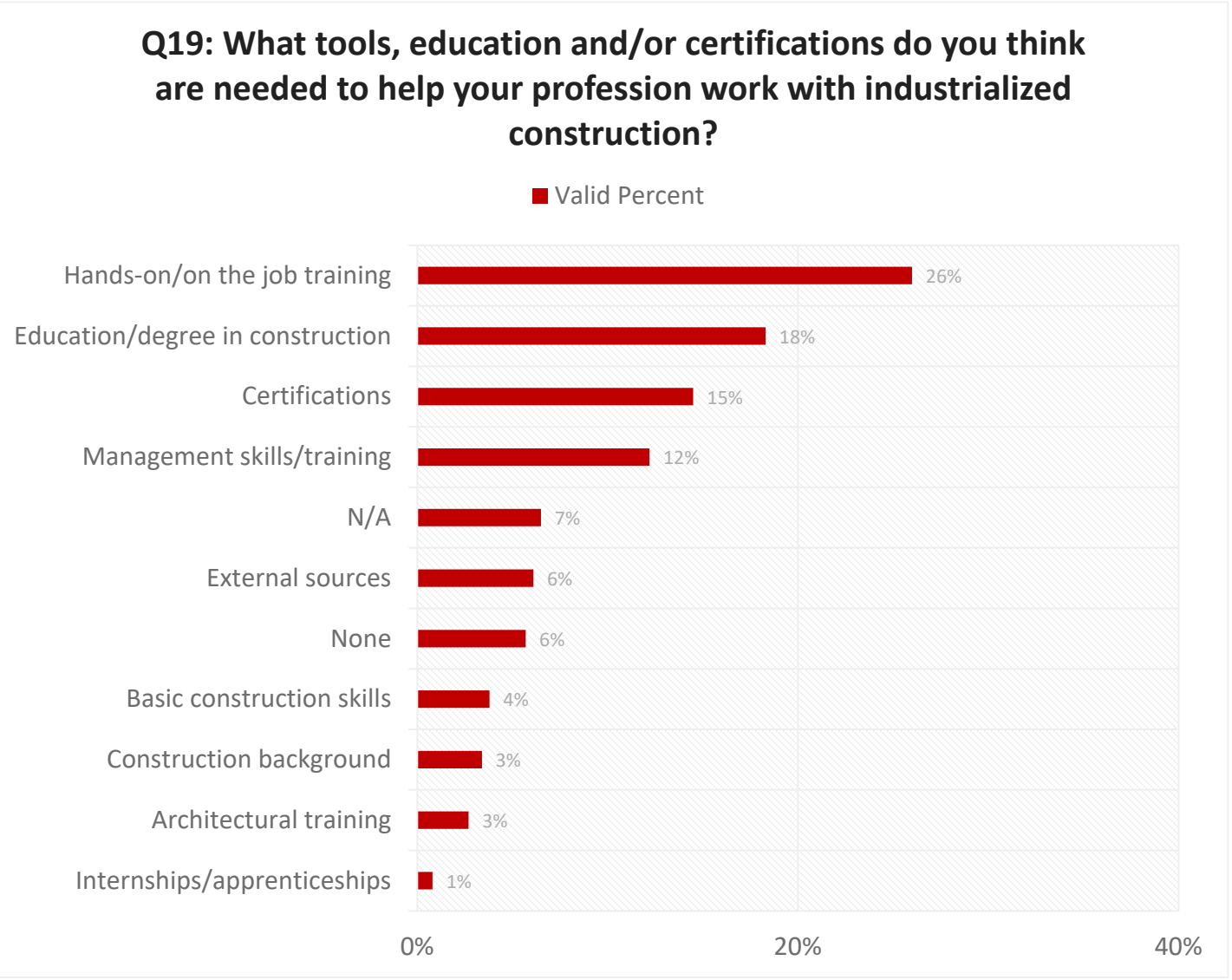
How can we best prepare the workforce to adapt to and benefit from industrialized construction?



Some examples of specific comments are:

"Learning how to do something new that is not widely trained or understood by most skilled trades."

"Becoming accustomed to getting work into a condition for modular setting and connection rather than final completion condition."

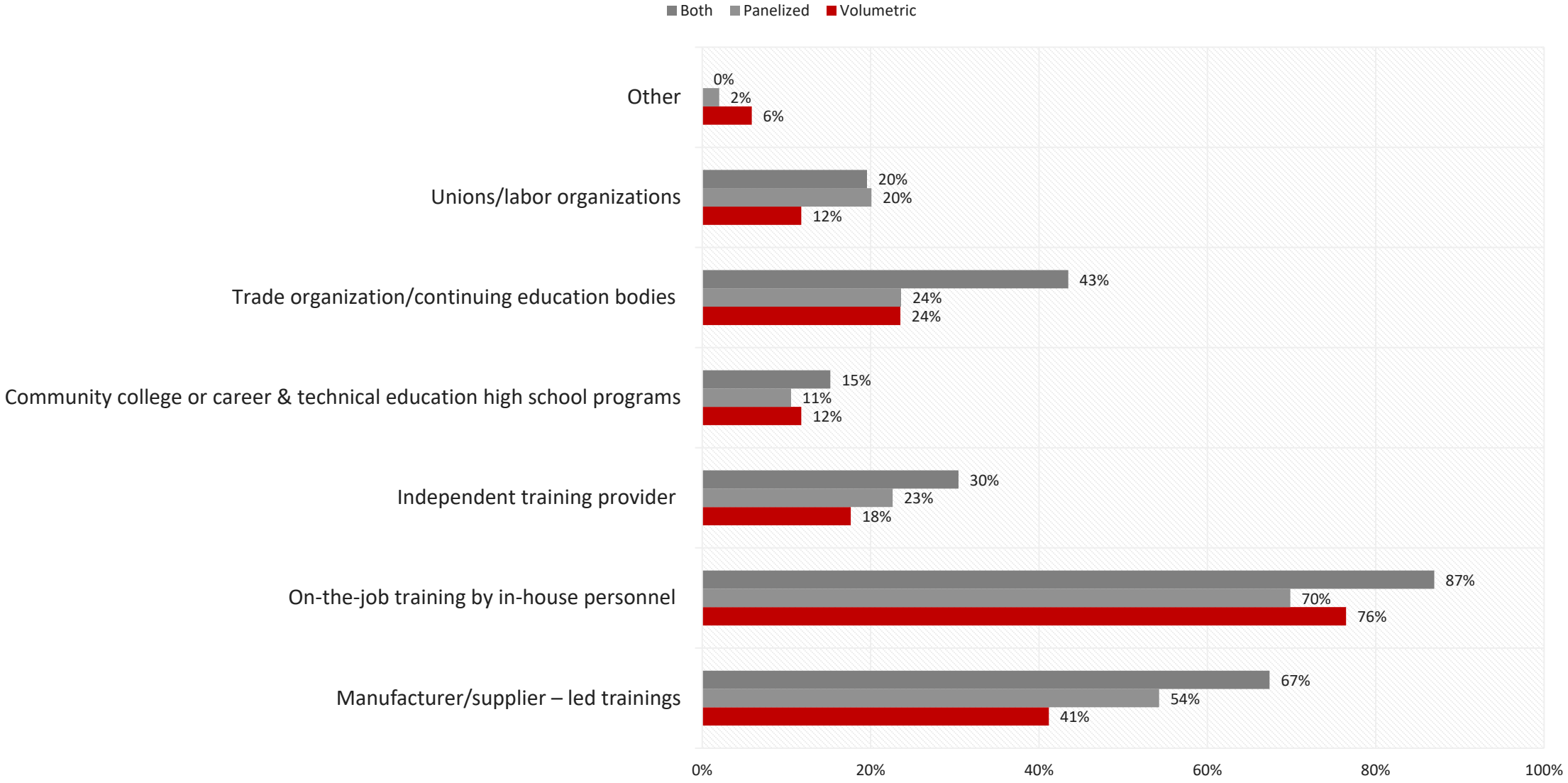


Example descriptions of specific tools and trainings provided by respondents:

"Any design program like, Autocad BIM AUTODESK 360 Adaption of tablet use in the field Laser measuring Certificate in ability complete ability to read and comprehend all drawing/design and specification documents Manufacturer Authorized intensive training."

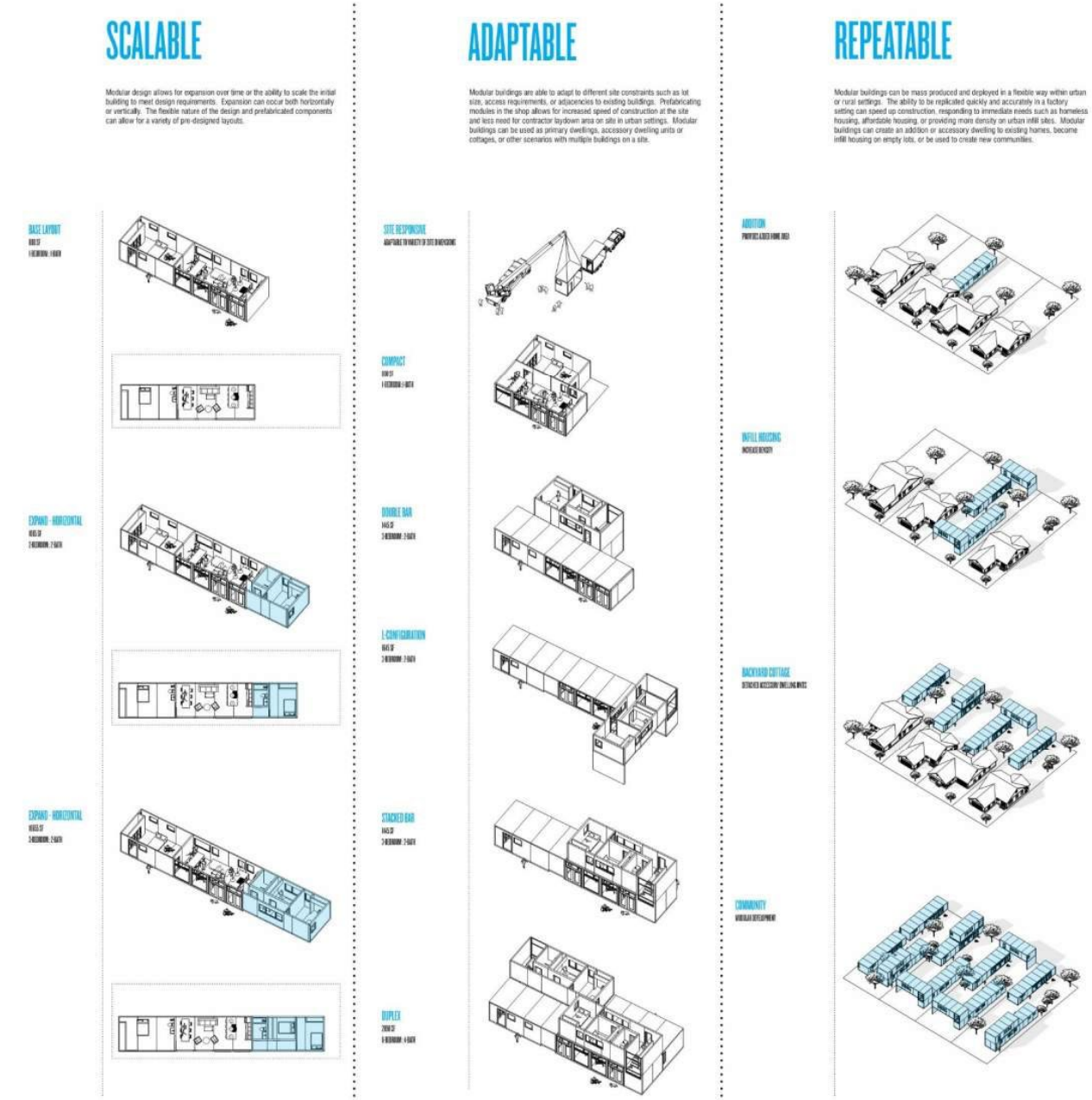
"A certification in welding and also proper personal protective equipment classes will be more helpful for the industrial construction future for all companies that are regarded in this line of professions."

Q15. **How does your organization train workers to have the necessary skills to work with volumetric/panelized modular projects?**



Q15 How does your organization train workers to have the necessary skills to work with volumetric/panelized modular projects?

	Contractor and Design Build	Specialty Trade and MEP	Manufacturer	On-site or Setting	Total
Manufacturer/supplier led trainings	86	19	37	4	146
	57.00%	41.30%	62.70%	66.70%	55.70%
On-the-job training by in-house personnel	109	38	40	5	192
	72.20%	82.60%	67.80%	83.30%	73.30%
Independent Training provider	31	8	23	0	62
	20.50%	17.40%	39.00%	0.00%	23.70%
Community college or career & Technical education high school	8	4	18	0	30
	5.30%	8.70%	30.50%	0.00%	11.50%
Trade organization/continuing education bodies	42	10	19	0	71
	27.80%	21.70%	32.20%	0.00%	27.10%
Unions/labor organizations	26	13	10	2	51
	17.20%	28.30%	16.90%	33.30%	19.50%



Matt's Place 2.0 Miller Hull Presentation, 2022

INTERVIEW DISCUSSION

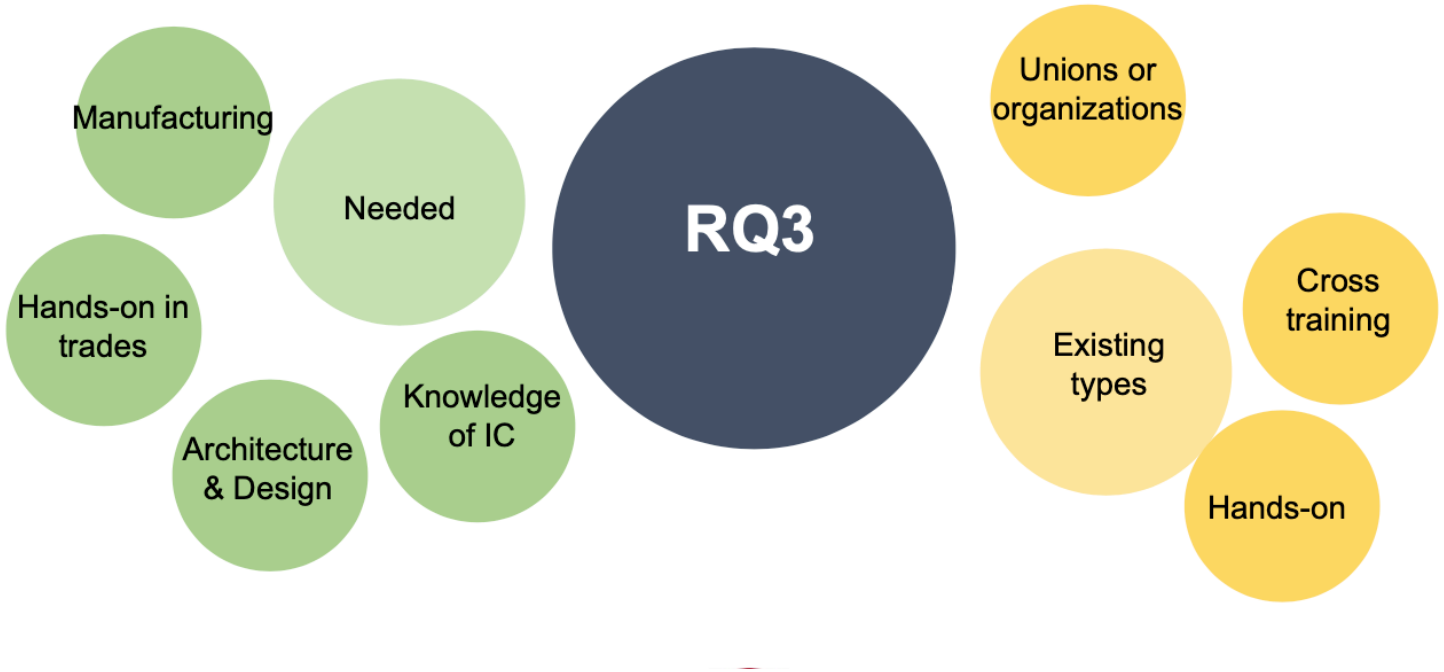
RESEARCH QUESTIONS | Training + Engagement:

What training exists, and what needs to be put in place?

How can we best prepare the workforce to adapt to and benefit from industrialized construction?

INTERVIEW DISCUSSION RQ 3+4

Figure 3: The figure below documents some of the key codes and themes that emerged from RQ3.



"Like with any profession, there's always going to be a learning curve. However, I feel like **on the job training** is the best way to get people the skills that they need to be successful. And thankfully, within the construction industry, it's very hands on."

*"Yeah. I think the two biggest challenges for volumetric modular construction is obviously **transportation**. That's easy. And the other challenge is **permitting in different jurisdictions**. Those are the two ones. And until **we get some standards** for things like that, it's very, very difficult to have any synergy for manufacturing."*

*"I would say that **the knowledge-based lack of training is with that integration of the manufacturing process with the design** of project. How do you take that design and the way the materials are put together and utilize our products to put together a prefabricated component that that is going to be acceptable to the marketplace and save time, and be easy to install."*

DISCUSSION RESEARCH QUESTIONS | Employee Impacts:

Where are the opportunities to expand the workforce to include more diverse populations?

How will working conditions and wages evolve under different scenarios of IC?

INTERVIEW DISCUSSION RQ 5+6

Potential future IC job candidates will experience far fewer physical demands in the workplace than in traditional construction. Because of this ability to hire people who may not have the physical strength or stamina to participate in construction on a jobsite, IC is becoming more appealing and CAN lead to an increasingly diverse workforce. This also increases opportunities for individuals who may not have opportunities in traditional construction areas or projects.

These individuals include:

1. *Women, particularly due to the flexibility of employment options, more consistent schedules*
2. *People not originally in construction or who may not have considered it as a career in the past*
3. *Younger generations*
4. *International populations and immigrant workers*
5. *Single parents with limiting schedules, those with certain cognitive or physical disabilities*

BUT, there is still wore work to do…

Results and Discussion

DISCUSSION BY RESEARCH QUESTION

Topic	Research Questions
Industry Workforce Changes	Where are the opportunities for new skills, job categories or occupations, in what IC scenarios?
	Where are the dislocations (i.e., what job categories will be displaced), in what scenarios?
Training and Engagement	What training exists, and what needs to be put in place?
	How can we best prepare the workforce to adapt to and benefit from industrialized construction?
Employee Impacts	Where are the opportunities to expand the workforce to include more diverse populations?
	How will working conditions and wages evolve under different scenarios of IC?

Results and Discussion

DISCUSSION

Final Thoughts and Next Steps

- We still have a bit more to do with data analysis, but based on the interviews and literature review, it seems there are a lot of opportunities for IC --- whether that is job opportunities, interfacing with EE technologies, carbon and waste reduction, and more.
- As with any research project, there were several limitations to this study – but overall, we found a lot of potential benefits with this approach to construction.
- More work is need here!

DISCUSSION CONTINUED:
WHAT QUESTIONS DO YOU HAVE?

Thank you for your time! Any questions?

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1. **QUESTIONSA THAT BELONG IN THIS SECTION**
2. Q14 – How well prepared is the current onsite construction workforce in terms of having proper training to support a significant increase in the adoption of the following construction practices?
3. Q15 – How does your organization train workers to have the necessary skills to work with volumetric and/or panelized modular projects?
4. Q16 – How much training would an experienced onsite construction crew, that is new to such methods, need to receive sufficient training to successfully construct the following project type(s)?
5. Q17 – How long would an experienced architect or structural engineer who is new to such methods, need to receive sufficient training to design the following project type(s)?
6. Q18 – How long would an experienced engineer who is new to such methods, need to receive sufficient training to design the following project type(s)?
7. Q19 – What tools, education, and/or certifications do you think are needed to help your profession work with industrialized construction? (Open ended responses)
8. Q28 – What do you think are the biggest challenges traditional construction crews will have in adopting volumetric and/or panelized modular construction practices? (Open ended responses)
9. GC2 – How do your daily tasks change when utilizing panelized or volumetric modular products compared to traditional methods of construction?
10. GC4 – What types of new technology or tools do you use on your jobsites to assist with construction?
11. MOD1 – How labor-intensive vs. automated is your manufacturing process from materials input to output of your product?

1. NU4 – What benefits do you see potentially coming from using volumetric modular or panelized modular products?
2. NU5 – What potential drawbacks or risks do you see in using volumetric modular or panelized modular products?

INDUSTRY WORKFORCE CHANGES