Transforming Construction: AI's Role in Building the Future

By Dr. Perry Daneshgari & Dr. Heather Moore

With each new change in process or technology, apprehension from users challenges the need to adapt their current methods and processes. When technology replaces an existing method or process, it is only sustainable if it offers something above and beyond what is currently in place. Some call this "disruption."

According to Clayton Christensen who coined the phrase *disruptive innovation* (when a need is not satisfied by existing providers), disruption will happen when a new provider begins meeting the unserved or underserved need and uses the technology to expand exponentially, toppling market incumbents. [1]

However, that is not always the case; for instance, development of new technology may be irrelevant to an existing provider's services, but once available, many derivatives of it can disrupt an existing provider's services — especially in the fringes and unrelated markets (e.g., fax did it to mail, Uber did it to taxi service and food delivery, Toyota did it to General Motors). All of these innovations don't have to satisfy the current wants, but they will need to address some of the needs that, when satisfied, will expand in the areas that were not known before. For example, Apple created an entire new ecosystem for app development by creating the iPhone and iPad. Everything came through inventions that are man-made, but their origin has always been in the nature.

Exploring the distinction between “man-made” and “natural” things prompts us to consider their origins. Regardless of the final product, the source of knowledge behind both is the same. Without delving into philosophical or religious realms, it’s essential to recognize that anything crafted or fabricated stems from human hands. Although the outcomes (positive and negative) can vary significantly, the origin of creation traces back to a non-artificial intelligence.

ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) is the new buzzword trending in the news, research, books, and social media. It has caused debate, core questions, and incredible advancements in information transfer. But how will it impact construction?

Will ChatGPT send prefabricated assembly instructions to a 3D printer? Will robots fix the workforce shortage problem? The answer to these questions (and more) is possibly, but not without Agile Intelligence™. Having knowledge about work and the experience of using tools to build is strictly human.

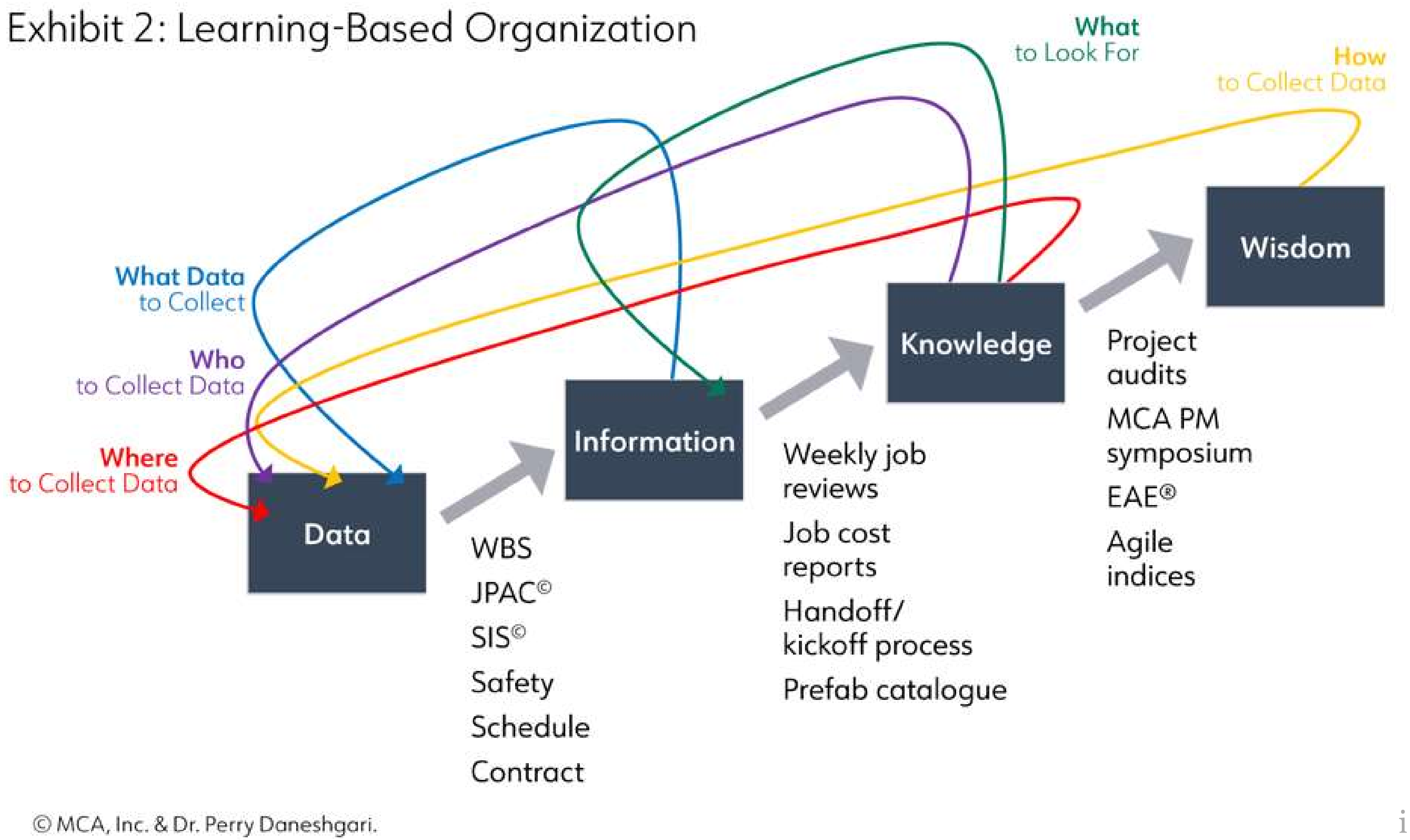
Exhibit 1: Key Definitions to Explain AI

Term	Definition	Construction
Technology	Systematic treatment of art or craft	Work Breakdown Structure
Information Technology (IT)	The study or use of systems (especially computers and telecommunications) for storing, retrieving, and sending information	Database management of: Estimating Accounting Work/Operations
Intelligence	The ability to acquire and apply knowledge and skills	
Artificial Intelligence (AI)	The theory and development of computer systems that are able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages	Modeling and simulation such as: BIM Workflow Logistics Industrialization

© MCA, Inc. & Dr. Perry Daneshgari.

i

Exhibit 2: Learning-Based Organization



Technology has always helped to move from one step to the next or increase the pace of evolution. To better understand how AI will impact construction, we can look at the industrialization of other industries such as agriculture and manufacturing to move faster toward the Industrialization of Construction®. [2] This article explores the source of information as the crux, which has been coined as Agile Intelligence™.

TECHNOLOGY, INFORMATION TECHNOLOGY & AI

To better understand the role of *technology, information technology (IT)*, and *intelligence* in the Industrialization of Construction®, Exhibit 1 explores the connection and distinction of these words that build on each other to get to the definition of AI.

If AI is meant to reflect human intelligence, then where does that intelligence come from? If it is based on knowledge, then what is the source? The knowledge is *not artificial*; it's based on *data*.

Many companies have an abundance of data; however, it's the progression from data to *information* to *knowledge* to *wisdom* (as coined by Dr. Perry Daneshgari) that helps an organization gain intelligence through learning and asking the right questions of the data.

Exhibit 2 shows how the intelligence and experience of those with wisdom can guide teams or individuals on how to collect data. Those with knowledge can help guide others on what to look for, where to collect the data, and who should collect the data.

This is essentially moving up the AI chain— recognizing how to assemble data, translating it to information and then to overall knowledge, and finally, recognizing what those with wisdom know from their experiences and knowledge. [3] The result of this progression from data leads not to artificial intelligence, but rather to *Agile Intelligence*™, which is gained from experience and a human source that can be used to improve the system and organization.

INDUSTRIALIZATION IN OTHER INDUSTRIES

Technology played a role in each of the five steps of industrialization. [4] Once the *techne* — the art and skill — is understood and made explicit (through Steps 1 and 2), it can be improved upon with systematic treatment (e.g., technology).

In agriculture, advancements in understanding the techne started in the 18th century when universities and governments began studying what led to better yields based on what farmers did. Then they worked to develop a systematic approach using fertilizers, irrigation, crop rotation, and mechanization.

Eventually this technology became housed in machines that provided both physical and mental (decision-making) aid to the farmer. Exhibit 3 shows this advancement in machines first using hardware technology to replace human/animal muscle power and then using software technology to enhance human decision-making and improve yield based on a systematic approach. [5]

In manufacturing, the technological advancement of computing (IT) has mostly replaced manual and human computing, which allowed manufacturing to go through industrialization in one-third of the time that it took for agriculture. [6]

The Influence of Technology

Henry Gantt brought technology to manufacturing and transportation before computers existed (Exhibit 4). His study of the relationship between work, effort, and time led to improved planning, and therefore faster timing, better quality, and reduced waste (cost) in production efforts in the early 1900s, including significant contributions to the country's military production and logistics needs. [7]

Over the course of industrialization, computers have helped to take information storage and processing from human brains to machines, but the source of that information has stayed the same. As explained later in this article, the transformation of information and knowledge from the human brain to computers will happen through a Work Breakdown Structure, which transforms tacit knowledge to explicit knowledge by breaking down the work to the level of the operator's capabilities.

IT, and now AI, can only be effective in organizations that use it to evolve from people to process to procedures first. As explained in the January/February 2023 issue of *CFMA Building Profits*, AI maximizes the benefits of the company's tacit knowledge; the goal is to transfer information (from base to top) to be digitalized and ingrained in the company fabric as AI. [8]

Exhibit 3: Industrialization in Agriculture

Technology is the container for this information and its transfer, and it is developed to support and supplement industrialization through the following five steps:

1. Initial development
2. Trial usage
3. Proliferation
4. Control and limitations
5. Evolution

HOW INDUSTRIALIZATION WILL HAPPEN IN CONSTRUCTION

Through the same five steps of industrialization, construction will rely on the techne to develop and utilize AI. But what is the reliable source of data for this techne? Just like it was for the mechanics and farmers of centuries ago, it's in the know-how of the craft.

MCA, Inc.'s efforts to teach and capture Work Breakdown Structures (WBS) over the past two decades has built the basis for intelligence that is rooted in tacit knowledge, using the WBS process to make the knowledge and experience explicit with data. The "Agile Intelligence™ in Construction" sidebar expands on this with examples of the data being captured at a job, project, and company levels through Digitalization, Commonization, and Interconnection® (DCI Construction®).

In several prior *CFMA Building Profits* articles, it has been explained how DCI Construction® facilitates this process — by decentralizing the information about who does what, when, and where and transferring it with multiple processes and tools into a centralized database. This data can be tapped during project planning, execution, and closeout to aid in decision-making and modeling outcomes.

An example of this application in construction comes from studying the WBS and its process. As explained in "Jobsite to Garage: Prefabrication & Modular Construction,"[9] the outcome of a WBS is a visible and vetted plan for the job that can also be used to plan a project. While the outcome doesn't appear sophisticated, getting *all* the work and the *right* work on paper is a very difficult process — especially for tradespeople.

The quality of this plan via the WBS sets the stage for the job and is the source of intelligence of what is expected to happen. Although an estimator did some critical thinking and best-guessing and an engineer or designer created a concept that functions, the person who will lead the build of the job is like the farmer who will tend to the crop — knowing what they see and know is critical for building AI.

Similarly, the WBS must be captured as data. Rolling it up and throwing it away after a day of planning is painful (and has happened). Criticizing and trumping it with “that plan won’t work” or “this doesn’t match the estimate” is also dangerous because what shows up on the WBS is *exactly* the way the job will be built.

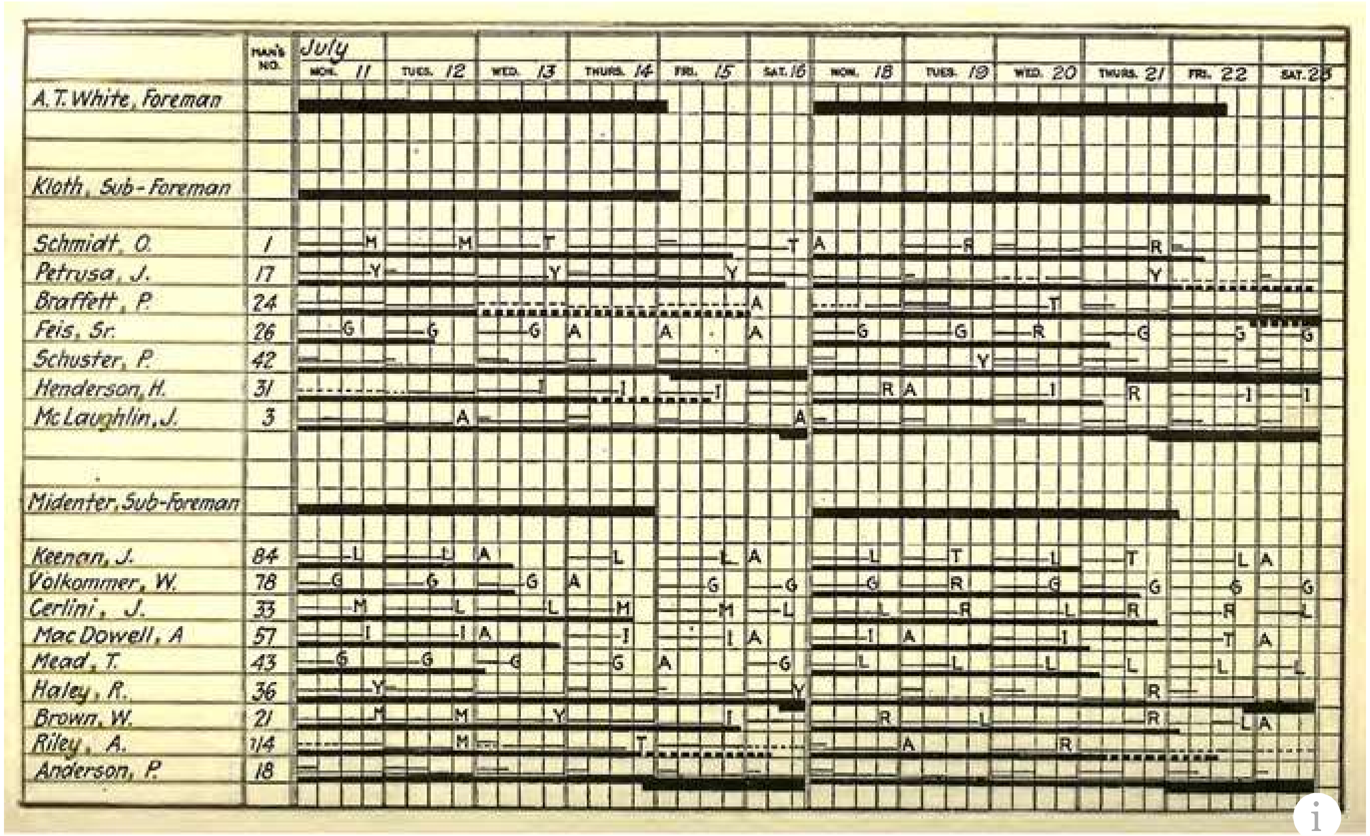
Technology — both in the form of hardware and software — can be used to aid decision-making and physical work as well as optimize productivity. The true AI in construction will be Agile Intelligence™, which provides the right information to the workforce to help them do the work rather than replace their work. The same took place in manufacturing and agriculture, and more recently, aviation.

The data source for this intelligence must have both a logical and social component. Modeling information flow on jobsites has shown that productivity improves when decisions include both:

1. Pure logic (based on an individual’s knowledge and experience)
2. Input from peers on the jobsite

It’s also known that there are different dynamics impacting the weight of these two factors such as job size, duration, and job stage (beginning, middle, and end). [10] In other words, it’s not enough to create AI out of pure job data. You will get something out of this AI, but it’s likely to be artificial rather than agile. Just like the industrialization of other industries, the source of data and decision-making needs to be the techne for AI to be useful.

Exhibit 4: Example of the First Gantt Chart



Agile Intelligence™ in Construction

The data needed to build Agile Intelligence™ has always existed — it's in the heads of the craft, the spirit of capitalism, and the soul of the company. The AI of construction exists at the job, project, and company (also known as project delivery) [11] levels. These currently and mostly exist as disjointed data and/or in disjointed databases; in some cases, they only exist in tacit form.

However, tapping into them, digitizing the production processes, commonizing the data structures and interfaces, and interconnecting the multiple databases (via DCI Construction®) will help transform this inadequate interoperability [12] to AI to increase construction's pace toward the Industrialization of Construction®. Let's look at some examples.

JOB

For the first two steps of industrialization (managing labor and managing work), the work on the job must be understood. This requires the field to break down the work into visible and manageable items that can be managed. This is suggested to be done via a WBS.

Then, the work should be scheduled each day through a system that explains not only what the labor did, but more importantly, what they planned to do; if it wasn't able to be done, why not? This allows management to categorize obstacles and work on the largest impacts to productivity.

This can be done via adherence to ASTM E2691's Job Productivity Management Standard [13] to understand common causes via Short Interval Scheduling (SIS®), for example. Then the common causes will link to special causes via labor productivity tracking (not production tracking) via a system like JPAC®.

PROJECT

While companies go through the steps of industrialization, the value transferred from craft to customer remains the same. Being able to transfer this value better, faster, cheaper, and safer is the role of the project manager (PM).

The data required also remains the same, although it is currently rarely interconnected. For example, the variables of work, effort, and time need to be linked, which can happen with Work Environment Management (WEM®). [14]

The financial management of projects also needs an interconnection between the accounting system and an operations structure (such as WEM®) that provides data about productivity, labor forecasts, and sources of money (e.g., change orders, committed costs, and horse trading15 with other contractors, vendors, and subcontractors) that very often the PM keeps in spreadsheets or in their heads. These can be made visible and accessible through modules that keep the outside-of-accounting data in one place and accessible to both the PMs and controllers.

COMPANY (PROJECT DELIVERY)

The way a project turns project results, both financial and customer satisfaction, into business results is through its approach to project delivery — it is the soul of the company and representative of the founders or current owners/executives. [16] It is where the CFO lives, and in construction, tries their hardest to predict the money and mitigate risk, all based on job and project information.

They need independent variables to predict accurately, and, unfortunately, their accounting systems can only hold one set of variables that are driven by finances. Separate estimating and operational databases need to be setup for system-level analysis of project performance, [17] dynamic budgeting, [18] and PM/overall performance and incentives. [19] The company variables are often managed tacitly by the CEO and CFO, absent AI that stores the data.

DCI Construction® is a process to digitalize, commonize, and interconnect items that are tacitly held (or even explicitly noted, yet not visible higher than the job level) and build them into the visible AI framework of your company.

CONCLUSION

With many unknowns about information management, AI can seem scary. But as always, humans will find a way to manage the new world so that it brings more good than harm. In translating that to construction, think about the source of intelligence in your role and current business. Most likely that techne cannot be easily replicated or replaced by outside hardware or software.

To learn from and avoid the same pitfalls as other industries that tried to use technology in the early stages of industrialization, you'll need to focus on the know-how within your business and use technology — including AI — to reduce physical strains/labor and bring high quality data-driven processes to your projects based on your data.

Endnotes

1. *"Disruptive Innovation." Clayton Christensen.* ***claytonchristensen.com/key-concepts****.*

2. *Daneshgari, Dr. Perry & Moore, Dr. Heather. "Competing in the New Construction Environment: A Compilation to Lead the Way." ELECTRI International. December 2016.*

3. *Daneshgari, Dr. Perry. "Founder's Transition: The Time Is Now." CFMA Building Profits. January/February 2023.* ***cfmabponline.net/cfmabp/01022023/MobilePagedArticle. action?articleId=1858490****.*

4. *Daneshgari, Dr. Perry & Moore, Dr. Heather. "Industrialization Update: Evidence and Projections." CFMA Building Profits. November/December 2022.* ***cfmabponline.net/cfmabp/11122022/MobilePagedArticle.action?articleId= 1839133****.*

5. *Moore, Dr. Heather; Daneshgari, Dr. Meik; & Parvin, Sydney. "Industrialization of Construction®: Signal or Noise, Threat or Promise?" ELECTRI International. March 2021.* ***electri.org/product/industrialization-of-construction-signal-or-noise-threat-or-promise****.*

6. *Moore, Dr. Heather & Parvin, Sydney. "How Industrialized Are You? Measuring Your Company's Progress" CFMA Building Profits. November/December 2021.* ***cfmabponline.net/cfmabp/11122021/MobilePagedArticle.action?articleId= 1743447****.*

7. *"A Look Back: The Fascinating History of Gantt Charts." Wrike. July 29, 2023.* ***wrike.com/blog/history-gantt-charts****.*

8. *Daneshgari, Dr. Perry. "Founder's Transition: The Time Is Now." CFMA Building Profits. January/February 2023.* ***cfmabponline.net/cfmabp/01022023/MobilePagedArticle.action?articleId=1858490****.*

9. *Daneshgari, Dr. Perry & Moore, Dr. Heather. "Jobsite to Garage: Changing the Mindset of Prefab & Modular Construction." CFMA Building Profits. March/April 2020.* ***cfmabponline.net/cfmabp/20200304/MobilePagedArticle.action?articleId=1656724****.*

10. *Moore, Dr. Heather. "Exploring Information Generation and Propagation from the Point of Installation on Construction Jobsites: An SNA/ABM Hybrid Approach." Dissertation, Michigan State University. 2013.* ***eric.ed.gov/?id= ED564574****.*

11. *Daneshgari, Dr. Perry; Moore, Dr. Heather; & Daneshgari, Jennifer. "PMs and CFMs: Increase Information- Sharing to Improve Profitability." CFMA Building Profits. March/April 2021.* ***cfmabponline.net/cfmabp/20210304/MobilePagedArticle.action?articleId=1669332****.*

12. *Gallaher, Michael; O'Connor, Alan; Dettbarn, John, Jr.; & Gilday, Linda. "Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry." National Institute of Standards and Technology. August 2004.* ***nvlpubs.nist.gov/nistpubs/gcr/2004/nist.gcr.04-867.pdf****.*

13. *Daneshgari, Dr. Perry & Moore, Heather. "New Productivity Measurement Standard Affects Revenue Recognition." CFMA Building Profits. March/April 2012.* ***cfmabponline.net/cfmabp/20120304? pg=27****.*

14. *Daneshgari, Dr. Perry. Agile Construction® for the Electrical Contractor: Second Edition. 2009-2020.*

15. *Daneshgari, Dr. Perry; Moore, Dr. Heather; & Daneshgari, Jennifer. "PMs and CFMs: Increase Information- Sharing to Improve Profitability." CFMA Building Profits. March/April 2021.* ***cfmabponline.net/cfmabp/20210304/MobilePagedArticle.action?articleId=1669332****.*

16. *Daneshgari, Dr. Perry. "Founder's Transition: The Time Is Now." CFMA Building Profits. January/February 2023.* ***cfmabponline.net/cfmabp/01022023/MobilePagedArticle.action?articleId=1858490****.*

17. *Daneshgari, Dr. Perry & Moore, Dr. Heather. "Job Porosity: Identifying the Risk Factors for Project Financial Outcomes." CFMA Building Profits. September/October 2023.* ***cfmabponline.net/cfmabp/09102023/MobilePagedArticle.action?articleId=1926014****.*

18. *Moore, Dr. Heather & Daneshgari, Dr. Perry. "A Primer in Dynamic Budgeting: It's Easier Than It Seems." CFMA Building Profits. July/August 2022.* ***cfmabponline.net/cfmabp/07082022/MobilePagedArticle.action?articleId=1807420****.*

19. *Daneshgari, Dr. Perry & Moore, Dr. Heather. "Are Your PMs Ready, Willing & Able to Be Held Accountable?" CFMA Building Profits. May/June 2023.* ***cfmabponline.net/cfmabp/05062023/MobilePagedArticle.action?articleId=1886510.***

DR. PERRY DANESHGARI is President and CEO of MCA, Inc. *(**mca.net**)* in Grand Blanc, MI. MCA, Inc. focuses on implementing process and product development, waste reduction, and productivity improvement of labor, project management, estimating, and accounting. A frequent author for CFMA Building Profits, his current focus is on making productivity visible to everyone through digitalization, commonization, and interconnection™ as well as strategic planning and founder transitions. He can be reached at 810- 232-9797 and ***perry@mca.net****.*

DR. HEATHER MOORE is the Vice President of Customer Care and Support at MCA, Inc. ***(mca.net)*** in Grand Blanc, MI. A frequent author for CFMA Building Profits, she holds a PhD in Construction Management with a focus on information available from the jobsite work environment using MCA, Inc.'s processes and tools for Work Environment Management (WEM®). She has contributed to research as well as customer process implementation with MCA, Inc. Dr. Heather can be reached at 810- 232-9797 and ***hmoore@mca.net***.