

ViZZ Technologies – Know It All

Episode 6 – The State of Industrialized Construction (with Justin Schwaiger, Nate Kaylor, Nolan Browne and Daniel Hall)

There are lots of ongoing conversations in the AEC industry about the opportunities presented by industrialized construction and what companies need to do to get ahead of this trend. In the latest episode of our [Know It All podcast series](#), we asked an impressive group of experts about their thoughts on this construction method, what success looks like and how technology can help.

This episode, The State of Industrialized Construction, features insights from our own Justin Schwaiger, Director of Customer Success at Manufacture by ViZZ Technologies, as well as three other thought leaders: Nate Kaylor, Director of Innovation at Factory_OS; Nolan Browne, Founder and Chairman of ADL Ventures; and Daniel Hall, Professor of Innovative and Industrial Construction at ETH Zürich.

Justin and guests get together and explore different perspectives on industrialized construction, including tips for adoption, obstacles which can arise, and how teams can best collaborate to be successful. For anyone looking for more information on this trending topic, this podcast episode is a great place to start.

Read the full Transcript below to explore key insights:

Justin Schwaiger: Welcome to *Know It All*, the podcast about the future of construction. I'm your host, Justin Schwaiger, and today I'm joined by three friends and construction industry thought leaders: Nate Kaylor, Director of Innovation at Factory_OS; Nolan Browne, Founder and Chairman of ADL Ventures; and Daniel Hall, Professor of Innovative and Industrial Construction at ETH Zürich. Great to have you all here on the podcast.

Before we dive into our topic, the State of Industrialized Construction, let's take a minute and you can each introduce yourselves.

Nate Kaylor: I'm Nate Kaylor. I am the Director of Technology and Innovation at Factory_OS.

Nolan Browne: I'm Nolan Browne. I'm the Founder and Chairman of ADL Ventures. We build companies for corporations in the offsite industry.

Daniel Hall: I'm Daniel Hall and I'm an Assistant Professor of Innovative and Industrial Construction at ETH Zürich. Before that, I did my PhD studies at Stanford University where I was the founder of the Industrialized Construction Forum. And I still organize that today after about eight or nine years of events.

Schwaiger: Great. Thank you all.

Daniel, we'll start with you from the academic perspective in industrialized construction. What's your current research focused on?

Hall: Yeah, we have four different areas that we're working on and we're seeing a lot of attraction on the research side. I think there's a lot of efforts from our research group on resource efficiency and circular economy for industrialized construction. Then we've had a lot of work around project and design management specifically for digital fabrication and robotics technologies. We've also been looking at new business models for industrialized construction and how it's changing the business logic of firms. And we also have done some work initially on fabrication-aware design configurators, and now we're moving into a new project, fabrication-aware generative design.

Schwaiger: Great. Thank you. Looking forward to getting into more detail on all those topics. We'll move to Nolan from the VC and the business building perspective. What are some major trends you're seeing as an investor and what are you looking to get ahead of?

Browne: There are a couple really titanic shifts happening in the space right now. And when you take a look at how things are being financed, you'll start to see that the major private equity players are starting to play hard in the space. So that's one of the big stories here – PIMCO, Blackstone, Amherst – they're all getting in pretty heavy. So, from a capital perspective, that is something that everyone should be taking note of.

Also, if you saw this STO Building Group, for example, that's a GC that just didn't exist a few years ago. It's inspired in part by taking advantage of the offsite industry. Another big trend that we're seeing is the general contractors kind of backward integrating into the offsite space.

Schwaiger: Interesting. And Nate, from the modular factory perspective, tell us a little bit about Factory_OS. What are you producing and where are you focusing efforts for improvement going forward?

Kaylor: Yeah, at Factory_OS, we're a volumetric construction company. We have two factories in Vallejo, a city north of San Francisco. And from those two factories, we build volumetric boxes, and our throughput is around three boxes per day, and everything gets installed into those mods. They're finished with fixtures and appliances – everything out to the external facade. Then those get shipped out to a construction site and installed on site. That's the important distinction is that we do volumetric boxes as opposed to some of the other panelized systems you see in industrialized construction.

We have two modes of operation. We have a design assist mode, which we will work with an external architect to collaborate on a design and rationalize it into modular units. And then on the more affordable side, we have a catalog mode which leverages a catalog of repeating units to streamline things and keep costs down.

Justin Schwaiger: I was at the Industrialized Construction Forum, Daniel. Thank you for organizing that amazing conference. I was also at the Mass Timber Conference in Portland, World of Modular, and Advancing Prefab. We're just seeing so much momentum into this industry in terms of industrialized construction and offsite construction. There's a stat from the Modular Building Institute that the percentage of modular construction in the US has doubled from 2.5% in 2016 to 5% in 2021. We're just seeing so much momentum here. Lots of companies are approaching this in different ways.

Nate, you mentioned modular versus panelized. We're also seeing vertically integrated versus product platform. You know, some are capital intensive, some are capital light, some are

building factories for themselves, some are building factories to produce other people's products, some companies are developing their own products. Still, some companies are turnkey to a developer.

What do you all see as the next best business model, which of these models is going to turn out to be most effective?

Hall: Reflecting on the last eight or nine years of seeing all the new ventures in this space, we identified three kinds of themes of new business models that kept emerging. I won't go so far as saying which one I think is going to win, but I do see the trend. The first one that you had was general contractors who were kind of going back and creating spin out factories from their own starting point. Sometimes they were a spinoff like DBC was a spin out of DPR Construction or other companies, like Bolts Construction, were making their own factories in-house. Then you had the vertical integrated companies, Katterra being the biggest one. I don't know so much about Factory_OS, but I believe you guys are relatively vertically integrated.

And then there's been recently, I think in light of fears about capital intensive investments, this new group of what we call either digital systems integrators, or sometimes people like to call them the orchestrators. They don't own anything. They just try to coordinate the supply chain with a product platform or a specific way that they want to set things up. And so that has definitely been the trend. And in fact, we invited three companies that were new at this year's forum. I actually didn't know exactly what their business models were, and all three companies were kind of this orchestrator model. And we're seeing the same also in Europe. So, I think that's the definite trend right now.

Browne: If I can echo that, one of the themes that we see a lot of is silo versus end-to-end, and then this trend towards a common data environment to connect little bits and pieces of space, obviously like the era of Katterra was the era of kind of the vertically integrated organization. And there certainly are folks who are still pushing in that direction. But yeah, increasingly what you do see is that people are thinking of this as a system integrations play and connecting up the pieces.

Kaylor: Yeah. Nolan, to clarify, at Factory_OS, we kind of strike a good balance between vertical integration and then operating as almost a subcontractor on projects. And I think that's kind of what's key about being successful, trying to tackle too much in terms of vertical integration. The operations and data flows are so complex and difficult to truly integrate. And I think I see the most successful operations kind of figuring out how to strike a balance between those two things.

Browne: Hundred percent agree with that. There's advantages to both of those extremes. And if you can figure out the path between them, you can try to get all the benefits and minimize the challenges.

Kaylor: It definitely makes sense. Being on the technical side at Factory_OS, I'm dealing with integration problems constantly of trying to get data from our design models downstream into manufacturing data, build materials. In theory, it makes sense to have everything integrated so that it just flows end-to-end smoothly, but the kind of branches of complexity that happen just

from the nature of architectural design and construction, make that very, very difficult to do in a robust way.

Schwaiger: Nate, that's a really interesting point about integrations. I also see that as one of the problems or challenges of our time, getting all the software platforms to speak and get data to flow end-to-end throughout the process. Let's circle back real quick on the business model. Something I hear frequently from all these new companies that are emerging, whether they're vertically integrated or these product platform type integrator models like Daniel mentioned, is the question of whether they develop these products themselves. Is it necessary for companies to build their first real estate development project themselves to prove the model? Or how do people get around that if they absolutely don't want to be a developer?

Kaylor: Yeah. You would certainly have to prove a concept out somehow. I mean, to just try to jump into industrialized construction and try to build a project there's too many things to consider. It's got to be constantly tested and proved out before it can become an actual business model.

Hall: One consistent thing I hear from almost every founder when they do their first project is that they lose money because they're trying to get their product right. And they're industrializing it in a way that's not typical for the industry. And they're also trying to create a continuity and a lessons learned. So, they're really investing in doing things right. They're not trying to find the quickest and easiest way, which we often do in a kind of project-based orientation. But they're using this more building as a product or product platform approach.

One of my favorite stories from Randy Miller formerly of RAD Urban is when they were trying to get it right. They built the most expensive condominium in the history of Berkeley when they were trying to kind of figure out their product. But then they learned their lessons. It was a small project, and then they were able to scale onto future projects. And I hear that over and over from multiple founders that the first project is always difficult, but then the efficiencies and the lessons improve from there.

Schwaiger: Yeah. That's a great point.

Kaylor: Yeah. So, one thing that the CEO of Factory_OS, Larry Pace, is always saying, it's kind of his motto, is we have a crawl, walk, run expression. I think the founders of Factory_OS faced those same challenges early on. I think we're only about four years old now, but they're constantly saying they figured out how to crawl and then walk and then just kind of keep scaling from there until they're running.

Browne: So, at ADL Ventures, we've been doing some modeling for national strategies for some of these interested parties and offsite. And what we found was that it can be more than losing money on the first build. And it also depends on the building topology and the use case and what it's going to be used for.

Just as an example that we've looked at in the hospitality industry, when you come in with a new design that you're going to do repeatedly, we anticipate five to seven builds before you break even on the additional cost that you had to pay in order to get the product where it needs to be. Now that will vary from industry and use case. But it can be quite a few builds before you completely nail it.

Schwaiger: So, assuming you pick the right business model, you develop the right product, you figure out how to get your first project built, you develop it yourself or you find a partner who's willing to take a risk. Is there capacity for all the modular projects today to get built? Or do we need additional factory capacity in North America or in Europe? Daniel, from your perspective, do we have the capacity here to build everything that needs to be built?

Browne: We do not have the capacity here or worldwide. We're going to have to double or triple the output of the current facilities we've got, and we've got to go from having 50 factories in the United States to 500 if we want to hit our targets for 2030, in my opinion,

Hall: A hundred percent agree here in Switzerland and in Germany, Austria, Switzerland region, they have very good CNC fabrication experience with timber. They're continually receiving demand from North American companies trying to learn from them. And I think there is an enormous demand for not just the capacity of building the factories, but the actual knowledge of how to set up and operate the factories. And I think this is a really important point that sometimes we think, okay, if I just get some space, I get some robots and I put a couple press releases out then I'm going to have a successful factory, but this really takes a new skill set to enter our industry – industrial engineering. And then also the connection between the design side and the computational side with the industrial engineers. So, we don't have the capacity on the factory side, completely agree, and we don't have the capacity on the talent side. We need to educate more people on how to do this.

Schwaiger: Right. So, you've all hit on this point about software, about integrations and increasing factory capacity, integrating all the point solutions, providing these platforms where data will flow between the product platform and the factory. What are the largest challenges we're seeing right now in the industry from a software perspective?

Kaylor: So, I might start with this, because this is something I think about all the time. The biggest challenges we run into here is the fact that the workflows can vary so much between different companies. Not only is the product differentiated between different companies, but the processes and operations are all different. So being able to tailor a software solution to a specific workflow, you either have to tailor it or you have to adhere to it. And that can be a major challenge. So having some abilities to tailor the software to fit your workflows is the biggest thing that we need right now.

Browne: I want it to be a little controversial here and say that I do agree. That having been said, there is a certain beauty to software enforcing a manufacturing process, so enforcing good process. One of the things I worry about is if the software platform is too open, you can do too many things with it. You can just wind up automating a really bad process. That is not really a good manufacturing procedure. So, how do you square that circle?

Kaylor: That's a great point. It's almost like we need some kind of industry standardization around processes, almost like you see in typical construction, some kind of standardization around different processes that the software design can follow. And then then it's just kind of its best practices at that point.

Hall: I take a slightly different view on this in that I think it's not just a software challenge, but it's a kind of overall challenge, how do you embed the rules of fabrication and supply chain into the design space? For me, this is the biggest challenge that we've been trying to solve.

So how do we make sure that the designers can use a software, whatever it is, that then doesn't violate the future rules of manufacturing. Because I think we all know that moment when the designer says they want to do something and then a factory ROS says that we have to, but that's not exactly how we're set up. So maybe we need to kind of have some design review and we can have multiple iterations, and this can end up being a lot of wasted time and effort. And this is what we want to get away from. So that's where we had the rise of the configurators. I would call it.

Starting around 2015, I saw the first configurator from Project Frog. And we've seen now a lot of these configurators, Bryden Wood, in the UK, and they've now expanded to the US. They have a lot of companies that are developing these configurators. And I think that this has been a good step forward. It combines design and manufacturing knowledge, but I think also we're moving out of the era of configurators, and I'm interested to see what will come next.

Schwaiger: Dan, can you expand a little more on why we're leaving that era of configurators just as it's getting going?

Kaylor: Yeah, that's a hot, hot take.

Hall: I didn't want to say too much. I mean, configurators are really powerful, right? A configurator is a design tool that a manufacturer can give to someone and let them use and make sure they don't break the rules of their system, but they also are relatively restrictive. I think what we're seeing now is the parameterization of configurators. I look at what Intelligent City is doing in Vancouver and how they have a fully parametric configurator, right? So, it's really, you know, stretch out the floor plate to fit your available space and have the rules generate. We're actually trying to go one step forward on the research side. And we are trying to think about how generative design can actually have fabrication rules embedded in it so that you no longer are necessarily configuring and doing a rule-based system, but you can actually have a generative system that also connects to the fabrication system.

And we call the project the seven-day house. So, we say we want to fabricate, or we want to use generative design to create a design in one day, which, I mean, we all know generative design can do that now, but we also want to make sure that that design is connected to the fabrication processes. So, it can be fabricated and assembled in the next six days. We're not doing a foundation, so we cheat a little bit, but that's the approach we use for our seven-day house. And I think I see others that are kind of moving away from just thinking specifically about configurators but trying to think more about parametricism or generation of processes and product.

Schwaiger: Yeah. I'm seeing these two directions as well. There's one school of thought, which is let's focus on limited configurability. Let's try to get a web-based set of options for say a developer to go choose on a website and pick their options. Essentially build the building with, you know, a certain company's Lego blocks.

The other school of thought is more the Intelligent City parametric kind of flexible kit of parts type model where the manufacturing capacities can flexibly accommodate parametric changes. So super interesting. Let's pivot now to if you're a developer or if you're a general contractor, how do you get into an industrialized construction? How do you start on your first project? What

do you need to think about to make sure you're reducing some risk on this new type of construction? What are the things you need to keep in mind?

Hall: I haven't worked for a general contractor for a long time, but I really like the model that DPR construction used. I mentioned earlier but they've long been collaborators and partners at the Industrialized Construction Forum, and they basically spun out a sister company. I think they have a venture arm of DPR, and they invested and then got some other investments and founded Digital Building Components. And it was a standalone sister company that would sell to DPR construction.

I think this was a really smart move because it separated them from the internal politics that might exist when you try to transform a company. And it also allowed them to sell to their competitors, which for an industrialized factory, you need a certain amount of volume to pay back the investments.

They actually do sell some of their interior wall panels and exterior facade elements to also competitors of DPR construction. So, I really like that model. I have a company I work with here in Switzerland who's also trying to kind of evolve towards more industrialized construction and they're doing quite well, but one of the things that they consistently talk about is how difficult it is with internal politics. It's a very large general contractor, and there's always questions about what are you doing? The building is a product. You have a product now. And there's a lot of baggage that comes along with trying to transform an existing business. So, it's difficult. It's not easy for sure.

Kaylor: Yeah. I think every company that's trying to grow, every GC and developer, that's trying to evolve, they need to have some kind of integrated technology or innovation department that can look at what they've done successfully and think about how to start integrating some of these principles into their workflows. You can kind of look at some existing operations, you know, these parametric facades we see, but it's not your common construction, but a lot of these big metal facades are discretized, rationalized, and produced offsite in a factory somewhere, shipped out to site and assembled. That's just kind of a small version of what modular and industrialized construction is.

And, to Daniel's point, there's opportunities to start kind of absorbing those practices across the board.

Browne: When I was at Advancing Prefab in Phoenix about two weeks ago and talking to GCs, there were a lot of people saying that can't get fabricators on their projects. Everybody's booked out. And I think it's a really interesting dynamic now because to build a partnership, if you're a GC and you want to build a partnership with a fabricator, you probably have to give a lot more than you normally would've or agree to buy a lot more than you normally would've and have to kind of plan for a deeper partnership. On the one hand, it seems it's a lot riskier to get that far in that fast. On the opposite hand, when you start planning for volume, you're talking about economies at scale and getting there faster. So we may see that this stress to find the right dance partner actually results in an acceleration in the industrialization of the construction market.

Schwaiger: Interesting, Nolan, as you're thinking a lot about business risk and large corporations developing new products, industrialized construction products. I mean, if you're a real estate developer or a GC, and you're starting to think about building your own factory, is it important to, as Daniel suggested, do a spin out into a separate business to alleviate that risk, or do you develop it internally with a corporate innovation team? What, are some of the thoughts or strategies you pursue when helping companies through innovation like this?

Browne: The first thing I would say is that I often think about it from the developer or the owner perspective. And so, one model that we're seeing is that we're working with some large owners and helping them select the team. We've just got done with a national strategy for a major builder who wants to stick-built volumetric. We went through the economic modeling exercise, the optimization of the product. We got to a point where we knew where they wanted to build the national geographies. We were finding who we would actually want at three hubs with a GC and fabricator at each. And we want that team to build every single one.

We don't want to vary it up. It's just like a playing team sports. Right? If you change your baseball team or the people in your lineup for every single game, you're going to have a hard time winning a lot of games, just because there's a lot of miscommunications. People have to get into the groove of working together. And that's very much my perspective on how a jobsite works as well. So, the more builds you've done with the same GCs and the same fabricator on the same team, in the same area, the better and faster they're all going to get. So I think that's one way to think about how the space is headed and certainly something we've been working on a lot.

Schwaiger: Interesting. Lots of change for the GC, for the developer. Let's think about architects, engineers, suppliers of materials. Who's getting impacted the most by industrialized construction? And if you're in those seats, how do you get ahead of this trend yourself?

Browne: I'll answer from the building materials perspective because I know most about that angle. There's a silent existential threat to building materials manufacturers today because by 2030, we would expect a massive boom in the offsite market. And increasingly the fabricators are going to start demanding, not materials that are made for onsite, but materials that are custom made for offsite.

So, think about the different types of processes you can use in a factory, and people are going to want machines, equipment, and materials that will support faster times, faster throughput. And it is a fundamental kind of shift in the way of thinking about building materials, because for the longest time it's always been get the cost as low as possible and squeeze all the pennies. And now we're moving into a regime where actually, I don't mind paying a bit more, if you can speed up my fab line. So I think that's something that the building materials folks really need to get ahead of. And I think it's hard to see that it's a critical problem because the offsite market is still small enough. And everybody's sold out.

Schwaiger: Yeah. I'm hearing this from two sides right now. One is we just need to pick the off the shelf stuff. If your factory runs out of plywood, you can go buy plywood somewhere because of the supply chain challenges we're seeing right now in this current environment. Nate, from your perspective, is Factory_OS taking the let's keep the supply chain short approach? Or are you thinking about how do we help develop co-developed materials that are essentially built for offsite for your factory?

Kaylor: That's a great question. Material procurement supply chain is definitely a constant topic at Factory_OS for figuring out how we can innovate and leverage different technologies for strategic sourcing, to forecast out what we're scheduled to build, and then be able to strategically source as much as possible, but that's just kind of to keep costs down so that product remains affordable. But I think we'll have to figure out how to build more efficiently with materials so that the material can keep up with the demand for the product. The only solution I can see to that is to figure out how to build the product with less materials.

Hall: Yeah. Thanks for cueing me up, Nate. I will, I will jump in on that because I think no one set it up with the threat to the existing suppliers. What we see is that as soon as you start to industrialize and you start to control the processes, you also open up the door for all kinds of new materials and processes to enter in.

I'll give a couple examples. You could start looking at it as two of my colleagues do, they started looking at how to use optimal 3D printed form work or computational design processes to reduce the loads of prefabricated concrete slab. So, in the end, what you have is a concrete slab with the same structural capacity and 70% less concrete being used, right?

So, you now optimize your concrete, and have prefabricated concrete slab as a product. And as soon as you can create a repetitive process and get it accepted within the industry, no easy task, of course, you start to all of a sudden have huge opportunities. And we have, you know, roboticist, material scientists working on different ways in which we can think about, for example, digital concrete, hybrid systems, concrete timber systems, or bio-based systems and more sustainable materials. So, the opportunities for material suppliers in an industrialized ecosystem, let's just say, Nolan is just right, and now we have this huge boom in industrialized construction, there will be opportunities for new products to come in. And the question is who will fill that void? And I think it's a big opportunity.

Browne: I was looking at a factory up in Washington, not that long ago, it's called Forterra, they're using Swiss temporary housing technology, which when I look at it, it looks like it's built to last a hundred years. So that's temporary in Switzerland, I guess, but it looks great over here. But so, one of the big drivers for Forterra was, can we use a CLT panel to eliminate drywall completely? And it looks great inside, and there is no drywall. Now, if you think about on a manufacturing line, and I think Nate would probably be more authoritative here, when we were doing the models, it looked like the drywall scales one to one, in terms of if you double your square footage, you double the number of stations you need to have for drywall, because that's just a difficult process.

Kaylor: Absolutely. Specifically, like taping and mudding, I know is a major bottleneck because you're dealing with dry times. And so, it's not even just the material, it's the processes as well.

Hall: Yeah. And I think this is where we open up the opportunity for product innovation, right? Like do we really need drywall in the form that it exists today? I don't think so. I think we can have something else.

Browne: I had a talk at the Advancing Prefab Conference two or three weeks ago. And part of what I was saying was replacement is an option. Just changing what we use. There might be a lot of cool things on the shelf that didn't work before in a regime where we were still squeezing pennies, but now as we become a more advanced industry where we understand

manufacturing, and the goal and manufacturing processes better, I think there's a generation of products that we could rediscover.

Hall: I couldn't agree more. And it reminds me of something we also say around ETH in our robotics fabrication group, which I'm a part of, the brick is sized for the human hand. And that's intentional because the brick is intended to be placed by human on the construction site. But if you start bringing in more advanced manufacturing processes with pre-fabrication robotics, what is the new brick? And then you see examples.

For example, there was the robot in Japan, which many people have seen, it shows this humanoid like robot that's putting up a drywall on a construction site. And for me, this is the exact opposite of where we want to go. That's just saying, let's design robots to replicate the industrialized tasks that we want to do, and we'll call that industrial construction. I think rather we can be more imaginative and think about co redesigning. So, we redesign the product to make more sense and we designed the processes and by doing so we might come up with something completely new and, as you say, Nolan, then we might find new demand for these products that at one point people said, oh, I don't see why it's necessary. I've got a brick, but now maybe there's a whole new imagination.

Schwaiger: That's a great point. Daniel brings to mind an example of Autovol up in Idaho. They have automation in the factory that's lifting the sheets of plywood. The thing that I always hear is, why a 4x8 sheet of plywood. You know, it's just like you said with the brick, it fits the human body, a human scale. Someone can install it on site. Why not a 10x30 sheet of plywood that a machine lifts. And then similar to that, like the Autovol example, the machines are doing all the heavy lifting. So therefore, the possibilities for the factory workforce are greatly expanded. There are women, there are older folks, there are all sorts of people you wouldn't typically find on a traditional construction site because the automation and the factory production process is removing some of those heavy lifting components and allowing a more diverse workforce to be able to do the factory work.

Hall: Absolutely. And one of the most mature industrialized construction companies going at it for 25 years is BoKlok, who I have very good research relationship with through their joint venture of Skanska and IKEA. I visited their factory again in September, and the number of women in their workforce is 20%. And the Swedish construction industry on average has 2%. So they have a ten times the number of women working in their factory compared to the general average of the industry. It opens up all kinds of new opportunities, I think, to work in a factory environment.

Browne: I want to take the opportunity to comment on something, two things that Daniel said and how they fit together and the underappreciated role of academia in offsite construction today. The first thing is we really need to come at this with a white sheet of paper and just rethink, if you were an alien and land on earth and you were going start building buildings in a factory, what would you do given all the technology? We've got all the different types of materials. What would that look like? And that's an exercise that people in industry don't really get to do. You would never really have the R&D budget to get that done. So, academia and organizations like Hopper Institute are super critical in helping move that forward and design the building in the future.

And the other part of it, and it's something that Daniel had mentioned as well, is if you went out and you tried to hire the people you want to run these factories, these, you'd have a really hard

time finding them, even the people who are currently employed weren't trained for it at a school or anything. They learned it on the job, right? So, this is where I think the traditional kind of rift between the practitioners and the industry and academia has to narrow a little bit, in my opinion.

Hall: Yeah. I agree. And I unfortunately haven't seen it narrow as quickly as it needs to. And to speak to your point, a few years back, there was a company who said they were growing, they needed a new senior person. And they said, basically, we need someone with a half construction management background and half industrial engineering background. And they need 10 years of experience. And they said that person literally does not exist. So how are we going to find the people, the workforce that we need to expand? And so I've taken that on my own side to think about, okay, you know what, I'm teaching civil engineering. I'm not an industrial engineer, but I can start to introduce principles of industrial engineering and get these students to tour factories, have conversations about what product platforms look like, and at least start to move the needle on educating a future workforce that knows how to talk, not only to an architect as a structural engineer or construction manager, but also to a factory. And that's the new challenge, I think, for the construction management community, to educate.

Browne: Absolutely. And let's not leave out government because as they can play tremendous role if they get it right. But traditionally, and I'm not going to call out countries, there tends to be a separation between how the government is trying to stimulate the industry and support the industry itself. I would love to see people benefit from government support and get coordinated and be able to help use the labs. So that's another gap that we as an industry should really try to close.

Hall: Nolan stay posted on that. Hopefully some good news.

Browne: I'm looking forward to it.

Schwaiger: All right. Great. Well, as we wrap up, what's one thing you each are most hopeful to see emerge in the construction industry this year?

Browne: I think that this year could be the year where a very large national firm launches a strategy where they start fabricating the same product over and over again in geographically, appropriately set hubs with teams that are well trained to work together over and over and over again. I'm optimistic. We might be able to see it this year.

Kaylor: Yeah. So, what am I hopeful to see emerge? I have to say, I mean, just kind of riding this wave between all the developments in academia and industry and seeing things emerge. I'm honestly just looking forward to seeing what comes out in the next year, every different institution or company brings a new perspective to the problem. And it's always interesting to see what emerges

Hall: From my side, and I didn't speak very much about it, but I'm particularly passionate about seeing a connection between circular economy and industrialized construction. For those that are listening, that aren't aware of a circular economy, it's the idea that we need to move away from a linear economy where we take, make and dispose of products and circular economy enters into kind of regenerative cycles reuse. And then recycling is the last option, right. But we all, we try to reuse these materials and I think there's a really good and strong fit between industrialized construction and circular economy – much stronger than in the kind of traditional industry. And I'd like to see some, probably not big companies, but I'd like to see a new group of

startups and a new group of kind of influential thinkers really take this on. It's happening in the Netherlands, it's happening in a few places, but very slowly in industrialized construction space. So that's my hope. It's more of a dream but we'll see if it happens.

Schwaiger: Great. Well, thanks. Thanks to each of you for a super fascinating conversation. Really appreciate all of your time.

Go find Daniel Hall's research online, look at what ETH Zürich is doing in terms of industrialized construction research and work on circular economy. So much good work coming out of that institution. Check out Factory_OS, check out ADL Ventures to see what some of the innovators in our space are doing.

This is Justin Schweiger. Again, we're talking to Nate Kaylor, Nolan Browne and Daniel Hall. Thank you all. And subscribe to *Know it all to keep up with the latest trends and opportunities in industrialized construction*.