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Solutions for Maintaining Productivity in a Shrinking Workforce

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Construction companies work in a highly competitive market and often the smallest difference in how they approach project cost and productivity can determine their success. Also some of these companies struggles to take advantage of efficiencies in productivity when the gains cannot be easily observed. Within academia, there is an ongoing trend toward research that focuses on productivity and innovation that tackles some of the well know issues plaguing the industry. More recently, the labor supply worldwide is struggling to keep pace with the demand for construction services. In this research, four potential solutions addressing the labor shortage were identified in the current literature on robotics, off-site construction, wage re-evaluation, and vocational education. The study gathered electronic survey data from industry professionals concerning these potential solutions and discerned that off-site construction, wage re-evaluation, and vocational education seemed to be favorable options, while robotics were perceived as not ready yet. The remainder of the paper analyzes these results and provides some additional context to the responses from the various open-ended questions that were also collected during the study.

Key Words: Sustainable Labor Practices, Labor Productivity, Labor Efficiency, Labor Shortage, Construction Workforce

Introduction and Background

The construction industry is one of the fastest-growing industries in the United States. From 2020 to 2021, industry spending rose by 1.3% to \$1.45 trillion (Beaudoin, 2021). The trouble with this growth is that construction companies are struggling to maintain the workforce necessary to meet the demand of the growing industry. The Association of General Contractors of America surveyed 2018 general contracting firms and found that eighty percent of them had trouble finding qualified, skilled labor (Callanan et al., 2020). For instance, in 2021, just to keep up with the growing economy, more than 430,000 workers were needed in construction in the United States (Beaudoin, 2021). This number was

not met and will continue to increase in 2022. The growing labor shortage continues to create and worsen the schedule of work and budget overruns (Kim et al., 2020). These continued schedules and budget overruns lead to rising project costs and worsen the inherent obstacles associated with construction projects, including road closures, environmental impacts, and loss of revenue for the owner. The remainder of this section will highlight some potential workforce solutions found in the existing literature, along with advantages and disadvantages.

The first proposed solution is the use of robotics in construction. The use of robotics to replace human labor has the potential to reduce the number of people needed in construction as well as free up available labor to do other tasks that automation cannot. Also, the use of robotics adds a safety benefit because humans are not involved in some of the more dangerous tasks in construction. The use of robotics, however, is met with persisting opposition to new technology being introduced to the conventional construction practice (Brissi et al., 2022). Also, the technology is not sufficiently developed for full-scale use. When it is fully developed, there will be a production period before robotics are seen in numbers on construction sites. However, the early adoption of robotics could lead to an increase in research and development that would expedite the process significantly.

The second proposed solution is the increased use of off-site construction and prefabrication. Off-site construction is currently being practiced and is expected to grow to \$157 billion by the end of 2023 (Saad et al., 2021). Some contend that with off-site construction, a house could be built with less labor, 25% less budget, and in only 24 hours (Saad et al., 2021). The technology for this exists today, however, the industry and owners are apprehensive because the workflow and processes are still being refined. Also, the long-term resilience of this type of construction remains unknown, and some argue that off-site construction increases the burden of transportation and logistical costs – offsetting the proposed cost and schedule savings.

The third proposed solution is increasing wages to encourage more people to join the industry. However, increasing wages will cause project costs to increase. Furthermore, wages are sometimes driven by the current political climate in the US and other exogenous factors, such as the economic health of the market. In a recession, wages may tend to be low while companies correct for the economic downturn, and in a healthy market, wages can more freely move up. Others posit that this is not a solution. In a simulation study conducted by Kim et al. 2020, increasing the wages by fifty percent did not significantly impact the number of workers entering the field (Kim et al., 2020). This is the most used method in today's market, but it has some way to go before being a proven solution.

The final proposed solution is increasing the funding for vocational programs for high school students. Hopefully, this will encourage young adults to enter the field and make them aware of the benefits of working in the construction industry. While many high schoolers are taught from a young age that the only way to be successful in life is to go to a university (Callanan et al., 2020) there are other paths to be explored. One such option is vocational programs leading to career paths in the construction industry. However, according to Callanan et al., only 6 percent of United States high school students were enrolled in a vocational program, while countries such as the United Kingdom, Germany, Netherlands, and Japan saw a much larger percentage (Callanan et al., 2020). Exploring and educating this optional career path in the United States would be prudent.

Literature Review

There are many previous studies of labor shortages in the construction industry. Productivity in construction is a popular topic among the sources reviewed for this study. The need for improved

productivity was a guiding rationale in most of the past research on the topic of labor shortages. It was determined that the United States has the highest construction industry productivity numbers based on an analysis of four different countries: United States, United Kingdom, South Korea, and Japan (Lee et al., 2021). However, it is reasonable to assume that the labor shortage could soon be worsened by current legislation limiting or eliminating immigrant workers from the labor market. In the past, project costs due to immigration policy were increased by 12% (Golden et al., 2010). Moreover, recent metrics on skilled labor in the construction industry exhibit a continual increase year over year (ENR Skilled Labor Index, 2022). Despite the pandemic last year, the United States' construction spending hit an all-time high of just over \$1.45 trillion (Beaudoin, 2021). The increased labor demand brought on by the increased construction spending is at risk because skilled labor is aging out of the currently available workforce. The average age of construction workers surpassed the average age of the United States labor force for the first time ever in 2017, meaning more construction workers are retiring than are entering the workforce (Sokas et al., 2019). The lack of junior tradespeople entering the workforce can be attributed to a limited understanding of the opportunities that are available within the industry (Callanan et al., 2020). With the lack of a qualified workforce, the improvements in the cost, time, and quality of ongoing projects are in jeopardy.

Currently, the solution to this problem is increasing training to develop more skilled laborers. According to Tam et al. (2021), creating more training opportunities, including workshop programs, leads to increased worker productivity that can limit the labor shortage significantly. Furthermore, Kim et al. (2020) claim that a ten-fold increase in the training rate of laborers decreased overall labor shortages by 85%. While a ten-fold increase might be hard for some companies to absorb, Podder et al. (2022) claim that the training can be expedited by using current technologies, such as virtual reality, to simulate real-world tasks that will make workers more productive in less time than traditional on-the-job training. This proves that technology is already making a significant impact in the construction industry, and there are many other exciting technological advancements that are currently being used and developed.

The articles researched suggest that the most predominant technological advancements today are the use of offsite construction and the use of robotics. Saad et al. (2021), states that offsite construction has vastly increased construction productivity for the companies and projects that have adopted it, however, few companies have used it to its full potential (. As promising as offsite construction is, it can still be improved. Brissi et al. (2022) found that using robotics to produce and assemble modular buildings can reduce the amount of labor required and increase overall productivity even further. These articles provided many great findings considered in this research, however, the collected literature had research gaps that need to be addressed by future research.

The most common issue between all the articles is that the researchers did not have the time or resources to cover all the potential factors of their given topic. The construction labor shortage is a large and complex topic and cannot be covered by a single research group. Brissi et al., Lee et al., and Saad et al. all stated in their respective works that the topics covered were too wide to cover all aspects that could impact their research. Also, most of the research studies were conducted at the height of the COVID pandemic. Additionally, the recent research published could have skewed data because of the volatility of the construction market during the pandemic. Lastly, researchers also noted that they did not have enough participants due to COVID restrictions. These are among the more common factors that limit the validity of the literature, however, there are more specific factors that need to be taken into consideration.

For example, Tam et al. (2021) focus on the perspective of project managers and contractors without considering the workers' point of view. Sokas et al. (2019) only cover the labor shortage faced by

trade unions which only account for about twenty percent of the total labor force Callanan et al., 2020 faced limitations in their research regarding vocational programs in high schools because they found that students simply were not interested in joining the trades. Research on immigration's impact on the labor shortage conducted by Golden et al. was limited to only the Washington D.C. area, even though immigration issues are nationally pervasive (Golden et al., 2010). Lastly, the dynamic model proposed by Kim et al. was unable to disclose how different factors impacted the labor market within each trade, only the construction labor market as a whole was presented. Since these articles have limitations, they prepare the groundwork for future research regarding these topics.

The articles reviewed each provided their own ideas for how their work can be furthered by others in the field. Many of these suggestions consist of conducting similar studies but looking at different factors related to the respective issues. Also, COVID has been detrimental to the industry and surrounding research over the last couple of years. As the pandemic winds down, research should adapt to cover the labor market outside of the pandemic era. Offsite construction and robotics are both rapidly growing, and research will need to expand equally to stay on top of the most current technological advances. Overall, the labor market is a volatile subject, and innovative solutions need to be researched as quickly as new issues arise.

Methodology

The study used a survey method to determine construction professional's opinions on the current labor shortage, the causes, and their thoughts on the effectiveness of the proposed solutions. The survey was designed using an online survey and was categorized into three sections: demographics, current construction labor force conditions, and possible solutions. By using methods such as multiple choice, slider scale, 5-point Likert scale, and optional open-ended questions, the survey was able to give clear, accurate, quantitative, and qualitative results. When constructing the survey, the main objective was to develop strategies to help lessen the labor shortage's impact. By targeting superintendents and project managers of the construction industry, the survey sought to better understand the viewpoints of people that are dealing with the labor shortage daily. The first aim of the survey was to determine the demographic of the respondents. To do so, the respondents were asked whether they are currently in the construction industry and what sector of the industry they primarily work in. Next, the participants were asked their opinion on the severity of the current labor shortage. Following this, respondents were asked to answer questions on the four proposed solutions stated in the introduction. Finally, the respondents chose their overall most preferred solution out of the four factors of the study discussed in the introduction of this paper. The survey was analyzed and organized into a quantitative evaluation of the results.

Data Analysis and Results

The data was first gathered using an online survey and grouped into the following categories: Demographic Information, Background Information, Robotics, Off-site Construction, Increase Wages, Increase Funding to Vocational Programs in High Schools, and Overall Best Solution. The data was then consolidated into the following figures.

The survey was sent to construction industry professionals and received eighteen responses. Out of the eighteen responses, two individuals no longer worked in the construction industry, and therefore, these two individuals are others in this study, three worked primarily on industrial projects, and thirteen worked on commercial projects, as shown in Figure 1 (n=16).

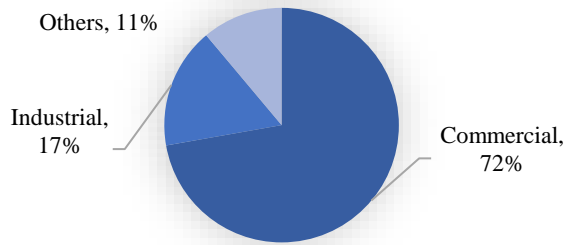


Figure 1. Demographics of the Respondents

Figure 2 is based on a question in the survey asking why respondents perceived there were inadequate junior workers entering the construction industry. Many respondents commented that the junior workforce was not aware of the opportunities in the construction industry. The other majority thought that they were aware of the opportunities but were not willing to work the hours or perform the labor that the industry demands.

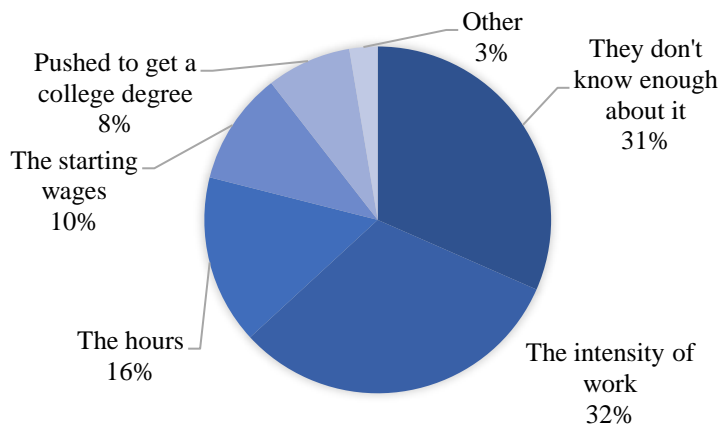


Figure 2. Detractors for Junior Workers Entering the Construction Industry

Figure 3 shows if the respondents agree that the solutions proposed in the introduction of this paper would be an effective treatment for the ongoing industry labor shortage. Most respondents would like to see an increase in funding for vocational programs in high schools that encourage young adults to enter the construction industry. However, most were unsure if technology and robotics would address the ongoing concerns for labor.

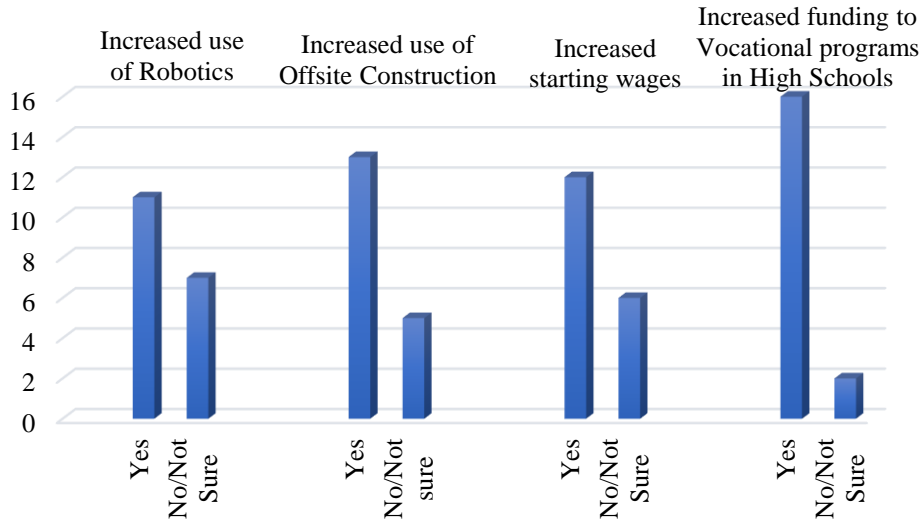


Figure 3. Industry Perceptions Regarding Proposed Workforce Solutions

The final question of the survey asked respondents which solution they felt would be the most helpful overall, as shown in Figure 4. The vast majority agree that increasing the funding for vocational programs in high schools is the best solution. Professionals in the field understand the urgency of the labor shortage, and an influx of young adults entering the field would provide the quickest and most economical solution for companies. Professionals are not confident that robotics or modular construction are the appropriate responses to the workforce problem.

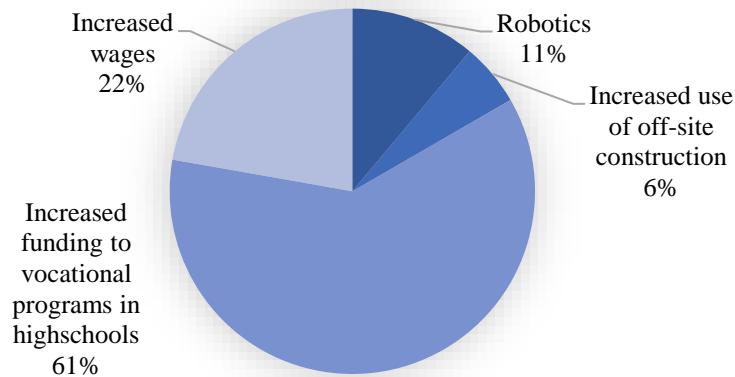


Figure 4. Ranking of Proposed Workforce Solutions (Industry’s Perception)

Discussions

Respondents had the option to voice their own opinions regarding the proposed solutions. For robotics, respondents stated that they are unsure about the technology, and even if the technology were available, it would have to be looked after by people, therefore not solving the labor shortage. Survey participants criticized modular construction for still requiring labor and not being able to adapt to the uniqueness of each site. Respondents were against increasing wages because increasing wages does not increase skill. Therefore, productivity stays the same or decreases due to layoffs caused by cost overruns brought on by increased wages. The only comment made against vocational programs in high schools was that the young adults would not take the classes seriously or the classes would not be taught well. While both may be true, the idea is that young adults are exposed to the industry, and that should increase the incoming labor force. Table 1 includes a full offering of the respondent's open-ended responses.

Table 1: Open-Ended Responses

Proposed Solutions	Open-Ended Responses
Unsure Robotics in Construction	<p>a. There are just some things that robots cannot do (at least not yet).</p> <p>b. Robotics are and will continue to grow in the industry. The field employees are and will receive special training to use this equipment.</p> <p>c. With every project being specialized and unique, there almost always needs to be human guidance and/or best judgment skills.</p> <p>d. Robotics seem like a good complement to human labor but shouldn't be embraced to replace human labor completely</p>
Unsure about off-site construction	<p>a. It takes labor to perform off-site construction.</p> <p>b. To grow a company and remain a top competitor, pre-fabrication is a must. It does shift field labor away from the job site, which always creates a more quality-controlled environment (better working conditions, less distractions, an increase in safety, and quicker turnaround), allowing less labor on-site with a faster construction schedule. This however allows a company to conduct more projects in which more labor is still needed.</p> <p>c. Don't have enough knowledge to form an informed opinion</p> <p>d. It cannot replace onsite because every site is different.</p>
Unsure about increase in wages to lessen the labor shortage	<p>a. Increased wages work sometimes, but if you constantly increase wages, someone has to pay for it. Increased wages usually lead to smaller crew size and more responsibility.</p> <p>b. Higher wages for the sake of it isn't the answer. There must be a correlation between pay, performance, skill, training, value-added and demand.</p>
Unsure about increasing vocational	<p>c. There will be people that take the classes to get credit. There will be people who take the classes and go into construction, and it will be nothing like the vocational courses that were taught.</p>

programs in high school	d. It is due to the blanket term of "construction". It is due to every trade having its advantages and disadvantages.
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Conclusion

The research shows that industry professionals lack confidence in a technological solution to the labor shortage problem. However, the industry is in such demand for labor that it will look at any option to help the workforce be more efficient. The leading solution that survey participants feel could benefit the most is increasing the funding for vocational programs in high schools. Thankfully, many other complimentary options are available to address the workforce shortage when considering vocational education and outreach. In the United States, national organizations such as Skills USA, the National Center for Construction Education and Research (NCCER), ACE Mentor, and the Construction Education Foundation of Georgia are actively working to address the workforce shortage issues. These programs focus on high school-aged children, and their impact has far-reaching implications for the industry. This research did not directly address these organizations, but based on the findings from the industry professionals, continuing or increasing the support of these organizations would mirror the desires of the professional that responded to this research.

The initial exploratory research findings are limited to industrial and commercial professionals, mainly in the Southeastern region of the United States. The data collected in this research only covers the opinions of professionals that could be reached with the electronic survey. Therefore, while it is difficult to generalize the findings in this research study to a larger population, it does provide a basis for applying the methodology to a larger and potentially targeted population. It is recommended that this study should be expanded to cover a broader portion of the country with a particular focus on increasing the response from trade disciplines that rely heavily on a skilled labor force.

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