Feedback Ungrading for Soil Mechanics

Meredith M. Kirkmann, M.S., P.E. University of Maine

Orono, Maine

Over three years grading practices in a Soil Mechanics and Foundations course have changed toward ungrading. Initially, homework grading consisted of 1) traditionally graded assignments, to 2) more simply graded assignments allowing for homework revision, to 3) the current feedback ungrading scheme focused on feedback and revision, until completion for homework, in order to increase student learning. Completion requires students to resubmit work addressing instructor feedback in weekly cycles until their homework is "Done," at which point it receives a gradebook entry of full credit. Ungrading covers a wide range of grading practices that could involve completely removing grades from the classroom, determining final grades based on student-instructor conversations, or more selective changes such as providing feedback instead of grades on some assessments. Research has shown that when comments and feedback on assignments are given with grades, students disregard comments. Only in the absence of a grade or summative evaluation of their work do students focus on feedback and comments from their instructors. For all three semesters, data was collected from class work activities, student surveys, final course grades, and grades on a multiple choice comprehensive exam. Student attitudes about revision and completion based homework grading were assessed at the beginning, middle, and end of the semester to determine how student comfort with this ungrading practice evolved throughout the semester.

Final research results include the yearly average course, exam, and multiple-choice comprehensive final grades, and assessment of student comments. Students indicated that while the resubmission process sometimes required additional work (which was not always enjoyed), and required that students continue their focus to older topics as the course moved on, it still had a largely positive affect. Student comments indicated that the revision work allowed them to learn from mistakes and understand material that in other grading and homework structures they would have instead moved past.

The study of increased student learning from assignments by providing effective instructor feedback and removing grades may provide instructors with insight into shaping their own grading practices and course syllabi to maximize students' learning and interaction with instructor feedback. One instructor goal is to more closely match the professional engineering practice of continual feedback and revision to engineering work until a project or assignment has been satisfactorily completed.

COVID-19 and Future of Construction Industry

| Boshra Karimi, Ph.D., and Mahdi Yazdanpour, Ph.D. | | | |
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| Northern Kentucky University | | | |
| Heighland Heights,KY | | | |

Introduction/Problem Statement: The construction industry has been suffering from lack of skilled labour and low productivity rate for a long time. Pandemic worsened the problem by supply shortages, however it had some silver linings to the industry. It forced the industry to apply new technologies which haven't been used before and explore more opportunities.

Research Objectives: The study objectives were to measure how construction industry has been affected by the pandemic, and investigating if the pandemic would affect the future of construction industry.

Research Methodology: The authors designed some questions to determine COVID-19 effects on construction and how it changes the future of industry. So, we assumed that construction was impacted by the pandemic, however we wanted to prove and investigate it via industry professionals' perspective to measure its scope and magnitude. The survey was conducted to collect professionals' opinions about COVID-19 pandemic effects on construction. The questions were validated by industry professionals. Total respondents were 83 professionals in the United States out of about a thousand of emails sent out between late 2020 and early 2021.

Results: Construction industry is suffering from lower productivity rate and lack of new technology application. Pandemic worsens the problem and dropped the productivity rates dramatically due to new safety regulations. Pandemic took a toll on the industry, however it assisted the industry to catch up with technology productivity rate later on. COVID-19 had some silver lining by expanding adoption of new technologies in construction project and increasing the productivity rate. Professionals stated that they used new technologies which never have been used before during the pandemic. 12% of professionals used drone inspection, 24% applied virtual reality, and 64% utilized webcams in their jobsites. Also, two-thirds of respondents are monitoring the site remotely. Moreover, about one-third of professionals moved to offsite/prefabrication due to the pandemic.

Research Impact: The results of this study will present as a poster and shared with the scholarly community in national and international level in order to expand the border of knowledge in this matter. Also, the results of this research will be shared with the students and make them pioneers in their field. Moreover, it will assist the industry to better cope with new reality of these days and alleviate the pandemic effects on the industry. As the result, all stakeholders of construction industry can benefit from this research.

Readiness Index for Assessing Building's Preparedness Against an Outbreak/Pandemic- A Conceptual Framework

Amna Salman, Doctoral Candidate and Anoop Sattineni, Ph.D. Auburn University Auburn, Alabama

Introduction/Problem Statement: With the outbreak of COVID-19, occupant health and indoor environmental quality have become a critical issue for facility managers. Anecdotal evidence suggests that most of the facility managers did not know how to minimize/mitigate the virus spread and could not maintain the full functionality of buildings. U.S. Centers for Disease Control and Prevention (CDC) indicated three means of virus spread: 1) Contact transmission; 2) Droplet transmission and; 3) Airborne transmission. The first two can be prevented if masks and social distancing policies are adhered. While the airborne transmission cannot be prevented even if the masks and social distancing policies are in place. This is very critical as human being spends 90% of the time indoors. Many measures were taken by different building owners and facility managers, however, most of these measures were reactive measures and their effectiveness is not fully known. We are still not out of the woods as data shows COVID related deaths, individuals contracting COVID-19 despite of the vaccinations, and virus mutation.

Research Objectives: Current research proposes layers of defense in the post pandemic era which should involve close collaboration between the architects, facility managers, mechanical engineers, healthcare professionals, epidemiologists, virologists, and builders. Therefore, the main objective of the poster will be to conduct interdisciplinary research to explore indicators to reduce the spread of virus in buildings.

Research Methodology: This goal of this doctoral research is to create a readiness index for facility mangers and building owners to assess building's preparedness against an airborne virus. The first stage consists of an extensive literature review and brainstorming sessions with the research team to identify key indicators for the readiness index. The second stage will consist of recruiting the identified Subject Matter Experts (SMEs) to conduct a Focus group to further improve and enhance the list of indicators. The third step will consist of a Delphi study to rank and weight the identified indicators.

Preliminary or Final Results: The list of indicators that were developed through extensive literature review and brainstorming sessions will be presented in the poster. The literature review showed that many modifications are required in the HVAC systems i.e., use of MERV 13 filters, dilution, and UV light. Another study used (natural ventilation) upper and lower vents along with balconies to evaluate the contamination in the air. Existing studies also recommended the use of the latest technologies to reduce the virus spread in buildings. Internet of Things (IoT) and Artificial Intelligence (AI) technologies were proposed to monitor, alert, visualize, and analyze the IAQ. These solutions can be used in educational buildings, workspaces, health-care facilities, and residential buildings to monitor the IAQ and, in turn, alert facility managers for any unusual values. Therefore, these indicators were vital and added to the list. The brainstorming sessions further enhanced the list by adding the mental health aspect of building occupants.

Research Impact: At present, there is no systematic framework or set of guidelines that building owners and/or facility managers can use to critically assess a building's readiness in an outbreak/pandemic. The goal of this research is to develop a building preparedness and readiness index system. The proposed index system will be a powerful, easy-to-use rating tool that would identify each critical element in the building which has an impact on the spread of airborne viruses and would present a knowledge-based quantitative system to assess the performance of each stated element

Reasons for Delays in the Design, Procurement, and Construction phases of Infrastructure Projects. A Structured Literature Review.

Farid Ahmad Orya, MSCM, PMI-SP and Maria Calahorra-Jimenez P.h.D.,PMP California State University, Fresno California, USA

Delays are well-known to be a major barrier to the success of infrastructure projects. Delays in project implementation result in additional costs and a decrease in financial returns, which results in a loss of revenue for clients and an increase in overhead costs for the contractor. Previous research has focused on the justification of the delay and identified the factors that cause project delays. However, these studies did not investigate the causes of the delays in terms of project phases.

This research aims to identify the main reasons for delays in the design, procurement, and construction phases of infrastructure projects. To this end, the following research questions are posed: a) How do the main reasons for construction delays relate to the design phase of infrastructure projects? b) How do the main reasons for construction delays relate to the procurement phase of infrastructure projects? c) How do the main reasons for construction delays relate to the construction phase of infrastructure projects? c) How do the main reasons for construction delays relate to the construction phase of infrastructure projects?

This study identified the main reason for delays in infrastructure by conducting a structured literature review. Using a three-step process, 40 out of 70 articles published between 2010 and 2021 were selected for the analysis. From these articles, first, the author quantified the reasons for delays based on the number of times that each of them appeared in different articles. Second, the reasons were then classified into three groups: design, procurement, and construction, based on where each reason usually occurred. The analysis found that 12% of the reasons for delays in infrastructure projects related to the design phase, 8% to the procurement phase, and 80% to the construction phase. The five top reasons per project phase are listed in the table below.

This research provides insight into the main reasons for delays in infrastructure projects' design, procurement, and construction phases. Identifying the reasons in each of the phases might facilitate the adoption of specific measures to mitigate those reasons. Thus, this research's findings might support owners, designers, and constructors aiming to mitigate delays in the projects involved.

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|-----|------------------------------|-----------------------------|------------------------------|
| No. | Design phase | Procurement phase | Construction phase |
| 1 | Poor design quality | Shortage of materials | Payment delay |
| 2 | Design change | Late delivery of materials | Poor site management |
| 3 | Insufficient data collection | Low quality of materials | Change orders |
| 4 | Approval of drawings | Price increase in materials | Poor planning and scheduling |
| 5 | Changes in scope | Changes in material types | Financial difficulties |

Top 5 reasons for delays in each of the project's phases

Comparison of Carbon Emissions of Modular and Site Built Houses

Maryam Kouhirostami; Abdol R. Chini, Ph.D.; and Robert J. Ries Ph.D.

M.E. Rinker, Sr. School of Construction Management, University of Florida

Gainesville, Florida

The construction industry has significant environmental impacts by consuming natural resources, generating waste, and emitting greenhouse gases (GHG) that lead to global warming and climate change. Globally, in 2018 the building sector accounted for 39% of energy and process related CO2 emissions. The residential sector contributes to a significant share of energy consumption and GHG emissions. The controlled factory environment and rapid assembly process of modular construction is increasing its use as a solution to housing shortage and affordable housing. This research is investigating potential of the modular construction in reduction of the environmental impacts of residential construction.

The goal is to compare the cradle to site GHG emissions of modular and site-built houses, and recommend measures, methods, and strategies to reduce the GHG emissions of modular houses. In addition, the study will determine the life cycle cost of the recommended measures and suggest methods and strategies to reach carbon neutrality in modular houses. This study also will conduct life cycle assessment analysis for a modular house and an equivalent site-built house within the scope of cradle to site (figure 1) to measure GHG emissions (CO₂, N₂O, and CH₄). The process based LCA approach will be used to estimate the GHG emissions of both cases. Data will be collected from several sources such as Ecoinvent, United States Life Cycle Data bases, GREET, a Modular House Factory, and a Construction site.



Figure 1. Cradle to site

The preliminary findings of this research based on literature review, interview with experts, and data collection result indicate that modular houses have lower environmental impacts compared to their comparable site-built houses; initial embodied emissions of materials have the highest percentage of total emissions of buildings; and traditional construction materials used in each region can significantly affect the building's environmental impact. For example, use of concrete or masonry construction materials has a negative environmental impact compared to steel or wood. The reviewed literature showed that the most common sources of embodied emissions are making and transporting buildings materials, construction waste disposal, transportation of prefabricated components to site, and resource and energy consumption during construction. Few studies included transportation of construction crew to the factory and to the construction site. In addition, bill of materials and interview results show that for modular homes, the construction cost is 10 percent lower in material and 40 percent lower in labor cost. The contributions of this research are as follows:

- Development of a set of recommendations to reduce GHG emissions of modular houses.
- Articulation of the technical complexities in implementing energy efficient and carbon-neutral measures in current manufacturing facilities.

• Identification of measures that could lower environmental impacts of a house in an affordable manner. This study would benefit construction builders and researchers.

Construction Worker-Drone Safety Training in a 360 Virtual Reality Environment.

Jiun-Yao Cheng, MSc, Lunardini Silva Mendes, MSc, Masoud Gheisari, Ph.D., and Idris Jeelani, Ph.D. University of Florida

Gainesville, Florida

Introduction/Problem Statement: Unmanned Aerial Vehicles (a.k.a. drones) are increasingly being used on construction sites, and such integration is posing construction workers who are already at a much higher risk in an even riskier situation. Considering such background, several research have been targeted on exploring the potential hazards that construction workers could encounter when working with drones on construction jobsites. In the literature, these potential hazards have been identified and categorized as physical risks, attentional costs, and psychological impacts, and several countermeasures have also been proposed to address these risks accordingly. Among the countermeasure proposed in the previous research, training interventions were considered as an inevitable and urgent needed measure to assist construction workers to face the potential challenges induced by drones.

Research Objectives: Regarding the urgent need of an effective construction worker-drone safety training material, the objectives of this study are to (1) develop a construction worker-drone safety training and (2) conduct the assessment of the learning effect and user experience of training.

Research Methodology: Considering the known effectiveness of learning experience through immersive training, the training material was created in a virtual reality (VR) environment and exported as a 360 video, providing an immersive device-agnostic experience that can be easily disseminated. The evaluation aims to provide an understanding of the effectiveness and user experience of the created construction worker-drone safety training. Therefore, a knowledge test about the basic knowledge of drones and relative safety challenges that were introduced in the video was performed by the participants before and after training to understand users' learning effectiveness, and a validated user experience survey was modified and conducted followed by a discussion on users' qualitative feedback to provide useful insights for improving future training material.

Preliminary or Final Results: Assessment of learning outcomes: participants' knowledge level significantly increased by 13%. This result reveals that the training video provided some valuable information for the participants. The user experience questionnaire adopts six criteria to measure user experience: engagement, immersion, emotion, experience consequence, judgment, and technology adoption. The results indicate that five criteria with at least acceptable reliability are better than average (2.5/5 or higher). Qualitative feedbacks from users were also analyzed and classified into six categories: Low video quality, Poor quality of animations, Use real human voice, Limited interactivity capability, Limited level of immersion, and Cybersickness and exhaustion.

Research Impact: The result of this study shows that the proposed 360 VR training video can effectively convey the knowledge for construction worker-drone safety and provide a good user experience. The outcome demonstrates the high potential of the designed 360 VR training content to serve as an effective training tool. Furthermore, several suggestions were derived from the qualitative comments from users, providing valuable feedback to improve the training video.

Virtual Collaborative Spaces for Online Site Visits: A PlanReading Pilot Study

Yuan Sun, Gilles Albeaino, and Masoud Gheisari Ph.D. University of Florida

Gainesville, Florida

Ricardo Eiris Ph.D. Michigan Technological University Houghton, Michigan

Introduction/Problem Statement: Site visits or field trips are widely recognized by construction educators to engage students in active learning, supplement traditional lessons, and achieve better student learning experiences. However, site visits pose significant logistical and accessibility challenges for educational institutions and teachers, limiting the number of students who can benefit from them. Moreover, the restrictions on site visits have widened recently, as the reality of COVID-19 public health concerns have compelled instructors to fast-transition to online course delivery, canceling the majority of site visits.

Research Objectives: This paper aims to address this challenge by creating a fully online device-agnostic experience where groups of students can easily and repeatedly experience site visits that were previously impossible, dangerous, or expensive to visit. This paper focuses on illustrating the development of such an online site visit environment and exploring students' learning experience and the system's usability by conducting a pilot study (i.e., construction-related plan-reading activity).

Research Methodology: Two steps were accomplished to achieve this goal. First, a virtual collaborative environment was created using Mozilla Hubs® to provide an in-depth learning experience through collaborative communication in a virtual space that resembles a real-world site visit to a building facility. Then, a plan-reading activity was conducted to understand students' learning outcomes within the virtual site visit and test the system's usability.

Preliminary or Final Results: Results showed that the online site visit effectively helped students learn 2D drawings interpretation. Moreover, the system displayed low marginal acceptability, which illustrates a slightly unnecessarily complex system with technical issues that might not be easy to use. The observed results within the online site visit indicated that students could interact with the virtual environment and collaborate within the shared virtual spatiotemporal contexts. Additionally, the web-based virtual collaborative space was easily accessible online, allowing student access with any device. Moreover, the technical development process to create such an online site visit is not complex. Mozilla Hubs® and other new virtual collaborative platforms eliminate the need for computer programming and reduce the time investment for course instructors to develop the digital spaces.

Research Impact: The study findings contributed to improving the existing online site visit in AEC education by creating a clear workflow of design and implementation of online delivery of spatiotemporal contexts of sites and offering an effective device-agnostic alternative when these learning opportunities are not available.

Study of Bridge Management Programs in the Northeast

Alec Kalogeropoulos and Michael Paniati, and Amine Ghanem Ph.D and Bilge G. Celik, Ph.D. Roger Williams University Bristol, RI

In the past ten years, the United States Government has devoted large volumes of resources into the country's infrastructure with the intent of reducing the amount of structurally deficient bridges. A recent study done by the American Road & Transportation Builders Association's (ARTBA, 2021) found that more than one-third of the nation's total bridges need structural repairs, rehabilitation work or replacement. The United States national average of structurally deficient or functionally obsolete bridges falls in the range of 24%. Rhode Island is the worst of any U.S. State, ranking last in overall bridge condition. Out of the 777 bridges in Rhode Island, approximately 56% of them are classified as structurally deficient or functionally obsolete (Federal Highway Administration, 2021). Across the nation, Departments of Transportation use a variety of bridge management tools and criteria softwares to determine the actual conditions of their bridges and to prioritize their rehabilitation/replacement work. This study explores the criteria currently employed by Rhode Island Department of Transportation (RIDOT) compared to the other Northeastern States to determine the selection order of bridge rehabilitation projects.

The objective of this study is to research and analyze the criteria currently being used to determine the selection order of bridge rehabilitation projects in the state of Rhode Island. Specifically, to compare the criteria being used in Rhode Island with the criteria of other Northeastern States that have better overall bridge conditions. The end goal of this study is to be able to provide the Rhode Island Department of Transportation with a recommendation of new criteria/weights that might improve their method in bridge rehabilitation or replacement classification process.

Authors intend to begin research by gathering information on various Northeastern States with similar conditions to those of Rhode Island, but with better overall rankings. These states include Vermont, New Hampshire, Connecticut, New Jersey, Maine, and Rhode Island. The data collection is done primarily through extensive online research to analyze similar states' transportation bridge management plans. Furthermore, the authors are contacting the appropriate bridge management personnel via phone and email for further information. Once a sufficient amount of data is collected, authors will analyze the criteria and their weights to determine their impact on the overall bridge prioritization processes.

At this point the authors are currently in the data collection phase of this study. Thus far, authors have received data from New Jersey, New Hampshire, Vermont, and Rhode Island regarding their bridge management processes. Authors are seeking more information from Connecticut, and Maine including but not limited to the weighting and scoring of the following components: condition, type & size, importance, capacity, and risk.

This study aims to assess the Bridge Management Processes used in these more successful states and compare them to that of Rhode Island. By collecting and analyzing this data, authors intend to identify similarities and differences between the Rhode Island Bridge management processes and the processes used by other Northeastern States. These similarities and differences will be showcased in this study. This study is part of a larger research to improve the bridges condition in Rhode Island by proposing a better selection process of bridge rehabilitation/replacement.

A Systematic Review of Blockchain Technology and its Applications in the Construction Industry

Bilge Gokhan Celik, Ph.D., Amine Ghanem, Ph.D., Audrey Corcoran, and Zachary Wakefield Roger Williams University Bristol, RI Yewande S. Abraham, Ph.D. Rochester Institute of Technology Rochester, NY

In a world with ever-advancing technologies and an increase in legal, technical, and managerial complexities, industries such as retail and manufacturing look a lot different than they did a few decades ago. However, the construction industry has been relatively slow in the adoption of emerging technologies to improve overall productivity, efficiency, and reliability. Industry 4.0 involves a digital transformation of production-related industries such as construction. Alongside many digital technology innovations associated with Industry 4.0, blockchain is a system that records information that is impossible to modify, offering a range of potentials for the construction industry. These potentials include streamlining the project management process and improving security, transparency, and convenience in areas such as smart contracts. This poster presents a systematic review of the current literature focusing on blockchain technology and its applications in the construction industry. This study aims to identify the major areas of application of blockchain technology in the construction industry. The authors started their preliminary research by narrowing the subject area from blockchain technology to more targeted research questions related to its application in the construction industry. After establishing these parameters, the authors developed relevant keywords including "blockchain," "BIM," "construction," "management," "building," "industry" in different combinations. Next, the authors identified several databases as the basis of their systematic review, including Academic Search Complete, Civil Engineering Abstracts, IEEE, and ScienceDirect. The authors then used the predetermined keyword phrases to complete searches on each database and created a master list of 552 published relevant scholarly work. Duplicates and publications that did not meet the inclusion criteria were eliminated, and the final list included 178 manuscripts. The authors are currently in the process of reviewing identified manuscripts through a thematic analysis in an effort to aggregate and compare the major themes commonly found in the current literature. These themes will serve as the basis of the results, including a list and analysis of all blockchain application opportunities in the construction industry. Preliminary results present several application themes for blockchain technology in the construction industry. An initial review of the final database revealed that blockchain's immutability, security, transparency, and traceability offer opportunities for improvement in a range of areas in construction, including but not limited to construction contracts, supply-chain logistics, building information modeling, and built asset sustainability. The authors will present an analysis of how blockchain technology can be integrated into current and future construction projects. This study is instrumental in guiding transformations to traditional processes while addressing a number of challenges through the integration of blockchain technology in the construction industry. The results of this study will allow researchers and practitioners to better understand new areas of blockchain applications and how they can add value to construction project management, processes, and the industry.

Symons Concrete Form Assembly Guide for Construction Management Students

William G Adams, Ph.D., and Christian A Geist

Colorado Mesa University Grand Junction, Colorado

Concrete is the 2nd most consumed material in the world, while water holds the number one place as the most consumed material. Annually, around 10 billion tons of concrete are produced. Concrete forming systems are used to sculpt this versatile material. The intent of this project, the Symons Concrete Form Assembly Guide for Construction Management Students, is to discuss use of concrete forms and instruct future students in the construction, assembly, planning, scheduling, budgeting, and close out of a concrete form project in a safe and efficient process.

As an applied curriculum project using a living lab concept, the aim is to introduce students to terminology for components used in the Symons Concrete Forms, assembly component terminology that crosses many brands of concrete forms used in the concrete placing industry. Johnston (1990) describes "Living Labs" as controlled learning centers for the student to experience and appreciate the materials used, labor needed, and the equipment of construction along with their relationship to the project site as a key element of a construction student's education. The problem addressed by Johnston is how to best train students in the visualization process that they need to develop to succeed in the construction industry, and how to create value in the construction education process by enabling students to gain experience without requiring unacceptably high levels of actual on-the-job field experience (Wentz, 1998). Through lecture and hands on application students learn proper terminology, best management practices on how to safely install the concrete forms correctly on a mock foundation footer, place concrete (no actual concrete is placed in this exercise), and safely dissemble the project.

Hands on, applied construction processes provide understanding for the novice construction managers for trade responsibilities allowing CM's to fully interpret the work of the trades, and likewise facilitates understanding for the owner and design team. Students have not professionally experienced the many sides of construction management; this curriculum creates applied experience with terminology. Classroom exercises coupled with field "living lab" assembly of the actual form materials provide awareness and confidence the student can take on a project site and implement at once.

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VR-Women: Immersive Storytelling Experience to Attract Females to Construction Educational Programs

Jing Wen and Masoud Gheisari Ph.D.

University of Florida Gainesville, Florida

Introduction/Problem Statement: Though research has been conducted to understand the strategies to increase female participation in construction, still the desired outcomes have not been forthcoming (Aulin & Jingmond, 2011; Kaewsri & Tongthong, 2014; Mappen, 2011; Perrenoud, Bigelow, & Perkins, 2020),. As of the latest labor force statistics, females represent only 8.4% of total construction managers (U.S. Bureau of Labor Statistics, 2021). Female participation is even lower in the construction trades (The National Association of Women in Construction, 2018). Several types of recruitment practices have been done to expose students to various disciplines. While these conventional approaches have helped and should be continued, there are certain limitations. For example, current limited female involvement in the construction field results in limited availability of female mentors/role models, where the supportive relationship with mentors/role models can only impact a small number of students. Secondly, while the exposure to the working environment (e.g., field trips to construction jobsites) has been identified as an influential and attractive factor for students to join the construction educational programs, there are a great amount of spatiotemporal and logistic challenges that limit students' exposure to real jobsite.

Research Objectives: The goal of this study is to provide a method to attract female students to the construction educational programs and ultimately improve gender inclusion in the construction field. This study proposes an immersive storytelling experience powered by virtual characters (VR-Women) and implement the social cognitive career theory (SCCT) as the conceptual framework in this study. VR-Women will be used to attract female students to construction educational programs by telling success stories of females learning and working in the construction field. Immersive storytelling integrates storytelling with a 360-degree immersive environment, where the audiences can actively observe unbroken views of a whole region surrounding the audiences. The major research objective is to develop VR-Women and evaluate its impact on students' cognitive changes towards the construction field before and after experiencing VR-Women.

Research Methodology: This study has three phases of (1) content generation, (2) platform development, and (3) assessment and evaluation. Phase 1 aims to identify the story topics and generate the story contents for VR-Women as a recruitment method to attract students to the construction field. In phase 2, the spatiotemporal contexts of the story will be captured in different learning environments and working environments to develop believable replications of the real world that complement the story narratives. Phase 3 aims to assess the influence of VR-Women and female students will be recruited to be exposed to the story. Their cognitive factors will be measured before and after the exposure. This project is currently at Phase 3, where VR-Women is evaluated by students.

Preliminary or Final Results:

- This study measures the personal and contextual influences on predicting students' self-efficacy, outcome expectations, vocational interest, and choice goals in construction.
- The study results can reveal the effect of VR-Women on four cognitive factors to better understand the potentials of immersive storytelling to recruit younger generations.
- The study will investigate how and what influences can explain or predict VR-Women's effect.

Research Impact:

- Provides female students an opportunity to virtually visit construction jobsites and be immersed in the interactive stories of female construction professionals
- Helps identify the targeted population that is most likely to be positively influenced by this technology.
- Helps fill the increasing gap of skilled workers in construction and improve gender diversity.

Enhancing Student Engagement in Learning through Gamification

Sharon D. Brown, MSCM, Cristina Cosma, Ph.D., PE. and Nathalie C. Bellemare, MSFM, RA Wentworth Institute of Technology

Boston, MA

While still controversial in its value added to knowledge delivery, Gamification - defined by Deterding et al (2011) as "the use of design elements characteristic for games in non-game contexts" - continues to gain popularity among educators and students. By adding gamification to the classroom, instructors seek to develop an active and collaborative learning environment, personalize learning, and make it more entertaining with the goal to increase student motivation and engagement. In their literature review Rabah, Cassidy and Beauchemin (2018) found support of the effectiveness of gamification in education in terms of cognitive, emotional, motivational, and behavioral outcomes. According to Pechenkina et al (2017) the usage of a gamified mobile app in class increased retention by 12.23% and improved overall performance by 7.03%. Overall supporters of gamification argue that this novel approach helps students develop soft skills such as collaboration, problem-solving, and communication which are as important for future success as the technical skills.

The study examines the impact three different games had on students' engagement in learning, in studying and in reviewing test subjects, and provides some lessons learned. The three games originally employed were: "Bingo", "Kahoot!" and "Jeopardy". Typical gaming mechanisms such as points, rewards, leaderboards, and countdown clock were used in various combinations. The goal of the first phase of the study was to understand and capture the perception of the participating students. In 2019 from a total of 124 CM students enrolled in 4 lecture sections slightly over 85% participated to the in-class gamified review of test subjects. The approach was continued in 2020 with 2 sections of lecture totaling 44 students. In fall 2021 the experiment was extended to CM juniors enrolled in the Project Management class – 4 sections totaling 105 students. The study is continued in 2022 both on-line and face-to-face with the CM freshmen and sophomores enrolled in Heavy Construction and Building Systems classes – 4 sections totaling 81 students and 106 students respectively. Between 2019 - 2021, the methods used to establish the impact of gamification on students' engagement were rational evidence and anecdotal evidence corroborated with faculty's own observations. In 2022 a standard survey with five questions using a 5-point Likert scale was conducted. Two open end questions for narrative responses were also added: "What did you like the most?" and "What could have been better?".

The preliminary results from students' comments and faculty observations demonstrate the value of gamification in enhancing learners' motivation and engagement. Results showed Kahoot as the preferred game with the highest impact on learning – in the 2019 experiment, 35% of the students improved their grade while Bingo had an impact similar to the traditional class, with 29% of students experiencing a grade improvement. Future work will quantify retention of concepts by analyzing test scores, comparison between gamified and traditional knowledge delivery, and correlation to learning objectives. The outcome of the study will allow CM instructors develop more individualized active learning opportunities and help increase student engagement and retention.

Keywords: Construction Management, Student Engagement, Motivation, Learning, Gamification

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Intelligent and Personalized LoRa-based Fire Evacuation System

Aiyin Jiang, Ph.D., CPC, Hemani Kaushal, Ph.D., and Zornitza Prodanoff, Ph.D.

University of North Florida Jacksonville, Florida

A total of 1.319 million fires were reported in 2017 in the USA, resulting in 3,400 fatalities, 14,670 injuries, and a financial loss of 23 billion US dollars. At the same time, there are various wireless technologies such as Wireless Local Area Network (WLAN), Radio Frequency Identification (RFID), Ultra-wide Band (UWB), and other wirelessly connected devices available, which can be used as a tool to reduce the number of injuries and fatalities caused during fire. It is estimated that about 67.3 percent of the U.S. population used a smartphone in 2017 and that the U.S. will have a 72.7 percent smartphone penetration rate by 2021. Out of various existing wireless technologies, Long Range (LoRa) technology uses unlicensed radio spectra which can be installed independently of the cellular carriers to deploy IoT devices in a wide area. This makes LoRa technology a very attractive solution for a dynamic fire evacuation system within a building.

The objectives for the proposed system are listed as follows:

(1) To improve the precision accuracy for the real-time indoor positioning system (RTIPS) using LoRa gateways and sensors

(2) To develop an intelligent and personalize evacuation routing system based on data collected from the sensors(3) To develop a cloud-based mobile App for the on-site application by integrating two systems: building information modeling (BIM) and RTIPS.

The accuracy of RTIPS developed by other researchers are between 3 meters and 5 meters through literature review. Such accuracy does not satisfy the urgent evacuation requirements within a complicated layout of a building. Hence, this project's targeted accuracy for a RTIPS system is within 1 meter. This study proposes the adaptive K value of K-nearest neighbor (KNN) algorithm to improve the RTIPS accuracy. The K value is determined by analyzing correlation between k-value and the received signal strength indicator (RSSI) from the Bluetooth beacon. The study is currently using a combination of LoRaWAN and Bluetooth Low Energy (BLE) devices networked together for a proof-of-concept implementation of the system infrastructure. Those, including beacons, various types of sensors such as temperature, smoke/soot, humidity, CO2 and CO, as well as people counters for occupation density calculation, are already deployed in a campus building.

In order to use LoRa technology, this study has already investigated communication system requirements i.e., data rate, range, time-on-air, spreading factor, etc., that best fit smart building emergency evacuation requirements. The research team has developed a cloud-service based server-end functionality through the use of the IoT-In-A-Box cloud service platform.

The project addresses community concerns regarding the response to emergency evacuation in the cases of building fires. The state of art by integrating LoRaWAN sensors, gateways, LoRa cloud services, building information modeling, and building fire safety services provides reference to the academia and practitioners an enterprise-level integration of fire-detection, alarm systems, and personalized and intelligent routing guidance.

Keywords: LoRaWAN, Fire evacuation system, Real-time indoor positioning system, Building information modeling, Internet of Things (IoT)

Increasing Diversity and Inclusion in Construction Management using an Online Virtual Environment at the Middle and High School Levels

Bailee Amaral, Alyssa Foerster, Guinevere Rhuda, and Anne Anderson, Ph.D. Roger Williams University Bristol, RI

Construction Managers only comprise 8.4% women, 3.3% Black or African American, 2.9% Asian, and 14.5% Hispanic or Latino (U.S. Bureau of Labor Statistics, 2020). Teachers, parents, and counselors have little knowledge of the construction industry, and misconceptions persist that jobs in the industry require brute strength and tolerance for inclement weather and bad language (Agapiou, 2002; Amaratunga et al.; Bilbo et al., 2009; Mathew, 2014). Systemic racism and unconscious bias have historically contributed to exclusion and lack of training opportunities for Black construction managers and laborers (Engineering News-Record, 2020). At a median annual wage of \$95,000 per year, construction management is one of the highest paid positions in the AEC industry (U.S. Bureau of Labor Statistics, 2019). Construction management can provide a fulfilling career opportunity with higher pay for underrepresented groups.

This study advances understanding of whether an intervention at the middle or high school level, in this case a "hands-on" workshop in a virtual environment, results in (a) eliminating the misconception that CM is not an appropriate career choice and (b) more underrepresented students applying to CM programs. The workshop included scheduling, estimating, site logistics, and safety activities, as well as an exploration of the RWU School of Engineering building using Quest 2 VR headsets. Some activities for our pilot study were conducted on paper but future workshops will be situated in a virtual world representing the Roger Williams University campus to show young students what the university looks like while exploring what a career in Construction Management may look like. Participant perceptions of construction management before and after the workshop were determined through deployment of surveys with a combination of Likert-scale and open-ended questions. Surveys also included participant demographic questions. 26 students participated in our pilot study. Our analysis found that 15% (4 out of 26) were interested in learning more about Construction Management given the opportunity. The construction industry can provide opportunities for underrepresented groups that they may not have realized they could achieve, such as fulfilling careers and higher pay. Findings from this study advance our understanding of how CM is currently perceived among middle school students and what actions can be taken to increase diversity and inclusion in CM programs.

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CM Coordination Issues during New Product Design

R. Casey Cline, Ph.D. and Kirsten A. Davis, Ph.D., PE, RA

Boise State University

Boise, Idaho

Within the construction industry, green building goals and environmental and climate change concerns have driven an increase in the number of new construction products and materials entering the market. Newer technologies, such as 3D printing, have also influenced the expansion of new products. Often, university research is the starting point for the new product development, but many times it is engineering faculty and students creating the products, with little or no knowledge of the construction industry. There is a great need for constructability analyses of product designs so that the final results can be used successfully in actual construction projects.

This work looks at construction management coordination issues during a multi-disciplinary research project developing a process for additive manufacturing of modular panels (wall, floor, and roof assemblies) predominantly from wood waste, utilizing a cold-setting process.

This project is a cooperative effort between two universities. One university is developing the product while the other provides feedback on the long-term usability of the product. The constructability analysis is made up of several feedback categories:

- panel construction, including size, finished surface, durability, precision, level of quality;
- transportation of panels, including long distance to the site, unloading at the site, movement on site;
- constructability, including connections, openings such as doors and windows, integration of mechanical, electrical, and plumbing; and
- end user final product, including fire ratings and finishes possible.

Preliminary results indicate that performing constructability analyses during the development of new construction products is a complicated, multi-stage, iterative process. A framework is in development to teach engineering students at the partner university construction related aspects that should be considered in their design. In addition, work is being performed to develop a second framework for teaching construction management students how to perform a constructability analysis during the design of new construction materials to help ensure that the final product design is useful and functional within the construction industry.

By sharing the work progression encountered on this project, both engineering and construction management faculty and students can be more aware of the process of development of new products, the role that constructability analysis can play in that process, and help ensure that a final product is one that is both suitable and well-designed for its end use.

Replumbing the School-To-Prison-Pipeline: Exploring Narratives in a Construction Education Urban High School

Kevin L. Hitchcock, MEng Auburn University Auburn, Alabama

The building industry needs trained workers from all backgrounds, but most individuals in construction are white. How does the experience of growing up in an African American neighborhood influence someone to pursue a career in the construction industry? One construction education program is trying to recruit youth from a predominately black, urban community to enter the field of construction while also addressing systemic issues of poverty, low home ownership and the lack of intergenerational wealth. This research started with the school-to-prison-pipeline narrative, asking is this narrative represented in an urban high school construction program? This study explores themes of how educators in high schools focused on construction education can shape how youth view of the construction profession and industry. This research has implications for the recruitment and training of a diverse workforce in building construction.

Analysis of a heat-related illness training program for industry workers

Peiyi Lyu, Raissa Marchiori and Siyuan Song, Ph.D. University of Alabama

Tuscaloosa, AL

Fan Zhang, Ph.D. University of Southern Mississippi Hattiesburg, MS

Heat-related illness (HRI) is a well-known health problem. HRI affects many industry workers since they frequently exposed to hot environments. Evidence supported that HRI can be prevented and decreased by using essential, low-cost measures, of which prevention training is an effective one. However, the numbers of HRI prevention training programs are limited, and the studies evaluating before and after changes in worker participation in prevention training are inadequate. Especially for workers with limited English proficiency, illiterate/low literacy workers and casual workers.

This study developed pilot HRI training programs for industry workers in Mississippi and Alabama. These training programs include information on recognizing heat illness categories, symptoms, risks, heat resistant clothing, proper first aid, and OSHA standards. They aim to increase the awareness for HRI of industry workers, prevent repeat HRI accidents and promote workplace safety. This research developed training materials and provided sixteen training sessions to around 80 workers from more than 30 small businesses. The training program created training materials adapted to the climate and culture of the South region of the USA, which are available in English and Spanish. Then some heat illness prevention flyers were developed to assess training outcomes. The Level 1 evaluation prepared a paper-based questionnaire for the evaluation of the training sessions. Trainees were asked about their training experience and perceptions of the training environment, the instructor, and the quality and usefulness of the training material. The Level 2 assessment was designed as a series of pre-training and post-training quizzes to check trainees' skills, knowledge and safety attitudes.

The results showed an average accuracy of approximately 87.68% for the pre-test questionnaire and 92.09% for the post-test questionnaire. The average increase in accuracy was 4.41%. It indicated that this training program is practical and valuable to the industry workers. The evaluation also showed that the trainees had a better understanding of heat-related illnesses after the training session. For Level 1 training session evaluation, over 84% of the trainees are satisfied with the presentation and the instructor. The benefit for workers to take this training would help themselves and others to stay away from heat-related illnesses and potentially save lives. Also, the success of other programs, including advertising, has dramatically increased awareness of heat stress in the Mississippi and Alabama regions. In addition, organizations such as AGC, PIC, ABC and GC helped broadcast the training program and the heat stress topic for safety training, further expanding the impact of the training program.

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Poster Title: Incorporating Industrialized Design and Construction in Construction Management Curriculum (undergraduate level)

Introduction/Problem Statement: Start typing here.

It has been decades since industrialized construction became a trend in building design and construction. However, the accredited construction management curriculum does not have a stand-alone course on this topic. Educational resources for this type of construction are limited to a patchwork of lectures, seminars, and publications globally. The building industry on the other hand is shifting to off-site construction where they are looking for future hires having skillsets in manufacturing to complement those in architectural, structural, and MEP design, and management. Industrialized construction is not only a new construction technique, it also brings manufacturing professions into the construction industry. Lean manufacturing, design for manufacturing and assembly (DfMA), and automation in design and manufacturing have been developed for the manufacturing industry for decades, wherein the construction industry is a burgeoning concept. The construction management curriculum requires modifications to incorporate such concepts into the educational model.

Research Objectives: This study presents a course model that covers the core concepts of industrialized construction including, the history, the differences in building techniques between conventional and industrialized methods, lean principles, DfMA, technology, and sustainability for construction management students. The course objectives include but are not limited to understanding the history, concepts, and typologies of pre-manufactured and industrialized design and construction, understanding lean concepts for construction manufacturing, relating sustainable construction tools and ethics to the business model of pre-manufactured construction, and using those tools to compare construction practices and learn the most recent industry innovations about Industrialization.

The course modules are categorized into six main sections: 1) history, theoretical background, and concepts (three modules, 3 weeks), 2) lean manufacturing techniques (two modules, 2 weeks), 3) project management (one module, 1 week), 4) design for manufacturing and assembly (two modules, two weeks), and 5) material and sustainability (two modules), 6) workshopping (one module, 4 weeks).

Research Methodology: *Start typing here*

This effort describes a newly developed Industrialized Construction course for undergraduate building science students at Appalachian State University. The students may have various backgrounds among three different program concentrations, architecture, construction management, and sustainable technology. The class exercises were designed to put students from various backgrounds in teams. In addition, class assignments delivery consists of quizzes and projects. The emphasis of the projects is learning through practice, reflecting both construction management project control and design for manufacturing and assembly skills. Students survey presented the evaluation of students understanding of the topic after taking the class.

Preliminary or Final Results:

The majority of students in both fall and summer 2021 had construction management backgrounds. Students understanding of industrialized construction was significantly improved. In the beginning, the majority of the students had known IC as just the shipping containers, whereas at the end of the class they can compare the differences between permeant and temporary modular structures. They learned how to design a structure with the choice of sustainable material and structure, and quantify materials they used in the structure. One of the challenges they were faced was a lack of competency in design skills, particularly structural design techniques. This course is now an elective junior-level class. It will be more appropriate for the students to take it at an upper level, the end of the junior year, or the senior level.

Research Impact: It is still premature to evaluate the contribution of the industrialized construction class to the skills of building science graduates. Follow-on research among other construction schools will be essential to identify the overall impact and to understand the best approach to incorporate the lessons in the construction management curriculum.

Poster Title: COVID-19 Severity and Vaccine Acceptance Among Construction Workers. Fahim Ridwan Nabil and Mostafa Namian, Ph.D. East Carolina University

Greenville, North Carolina

Introduction:

SARS-CoV-2, also known as COVID-19, has impacted all major industries in the United States. As this virus spreads by inhaling contaminated air from infected persons, construction workers are highly vulnerable to the disease. Workers have to work in close proximity in the construction industry, and the risk of breathing contaminated airborne particles containing the virus is highest. The construction industry is already exposed to various injuries, fatalities, and illnesses, and the COVID-19 virus made it more vulnerable.1061 deaths were documented in the U.S. construction sector in 2019, which means one worker died on an average every eight hours. Like other industries that had gone through the transition of work from home concept, the construction industry cannot adopt the concept as the industry relies on the expertise of individuals rather than machines. The whole scenario of COVID-19 in the construction industry is not known yet since there is a surge of COVID-19 again. The actual number of COVID-19 affected workers is still unknown, and the severity they have experienced. Vaccines reduce the transmission of COVID-19 disease and help to protect people who are vaccinated. As the construction industry is labor-intensive, workers can protect themselves and their fellow workers by getting vaccinated.



Research Objectives:

The vaccination attitude of construction workers in North Carolina. The severity of COVID-19 experienced by infected construction workers in North Carolina. The vaccination rate in North Carolina among construction workers and compare them to the national average of United States.

Research Methodology:



• According to the findings, the immunization rate for construction workers in North Carolina is 4% higher than the national average.

• 43% of workers are still not vaccinated, and among them, only 2% showed a willingness to take the vaccine in the survey study.

• 14% of the workers tested positive for COVID-19, and 5% of workers did not have any symptoms, 2% reported mild symptoms, 5% reported moderate symptoms, and 2% experienced severe symptoms according to the conducted survey.

Research Impact:

• Helping to understand the Vaccination attitude of construction workers. • To design the vaccination awareness training program for the construction workers. • To get an idea about the vaccination rate of construction workers in North Carolina.

Construction Safety and Health Monitoring using Wearable Internet of Things: Exploring Privacy and Security Considerations

Chinedu Okonkwo and Ibukun Awolusi, Ph.D. The University of Texas at San Antonio San Antonio, TX **Chukwuma Nnaji, Ph.D.** The University of Alabama Tuscaloosa, AL

Safety and health monitoring in the construction industry by manual observation is increasingly becoming difficult and susceptible to human errors due to the dynamic and complex nature of construction sites. Recent studies have shown that the Wearable Internet of Things (WIoT) has the potential to improve safety management by providing real-time information about the safety and health condition of construction workers for accident prevention. Of particular concern is the personal or health-related data collected from construction workers using these WIoT devices which are in most cases considered private, presenting the need to identify the type of health-related data collected, how the data is managed, the security challenges, system requirements, legal issues, and regulations guiding the data processing. This study aims to provide scientific information that can be used to develop an effective privacy and security framework to improve the adoption and implementation of WIoT for safety and health monitoring in construction. To achieve the above-stated objective, the study characterizes the concept of privacy and security concerning the construction industry, identifies the different construction safety and health data that can be monitored with WIoT, and systematically reviews the relevant privacy and security regulations for WIoT. A systematic review is carried out to characterize the concept of privacy and security, the different types of construction safety and health monitoring data that can be collected with WIoT devices, the IoT system challenges and requirements, and the applicable privacy and security regulations. The Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) is used for the systematic review to improve the quality of the review. Peer-reviewed journal articles related to privacy and security in the use of WIoT devices from ScienceDirect, Web of Science, and ASCE databases are considered. To obtain relevant information from the materials, a two-step approach is used by first reviewing the abstracts and conclusions to determine each article's relevance to the study, and then fully reviewing the entire article if passes through the first stage. The study provides scientifically backed information from the systematic review of relevant journals. The study evaluates the architecture of WIoT, the different layers and possible risks/challenges associated with it, and necessary security requirements for an IoT system. Different construction health data are identified and classified based on the method of data collection. Legal challenges impacting the adoption of WIoT in construction safety management are also identified and the necessary privacy and security regulations for safety and health data processing with WIoT are reviewed. The findings of this study are expected to inform the development of a functional privacy and security framework that will enhance the adoption of WIoT devices for safety and health monitoring in construction. The study is intended to provide scientific information for developing an effective framework that could provide greater privacy and security of IoT-based wearable sensing devices to enhance their adoption and implementation for construction safety and health monitoring.

Residential Drainline Challenges and Future Design Objectives

Margaret G. Carneal, M.S., NCIDQ, CKD, CBD and Annie Pearce, Ph.D. and Thomas Mills, M.Arch

Virginia Tech

Blacksburg, VA

Introduction/Problem Statement: Concerns of plumbing drainline issues are growing due to crumbling infrastructure, water conservation efforts, lower flows in drainline carry, outdated codes, pipe rigidity, and remodeling issues. The problem calls for a new drainline design, but first, the challenges of existing drainlines must be understood in order to develop new solutions. Plumbing codes have remained static for nearly 100 years despite dramatic changes in water usage in homes (Cole 2014). Documentation of drainline carry has not been collected outside of a laboratory environment (PERC 2016). This survey examines the challenges of drainline installation, remodeling, and service-repair issues in existing buildings from experienced plumbers.

Research Objectives: The primary aim of this research is to understand the current issues of existing drainlines in order to determine programmatic requirements for future innovations in drainline design. The following research questions were posed regarding the current state of drainlines in existing residential structures. What are the biggest challenges in drainline replacement? What are the causes of issues regarding drainline carry? Are water conservation practices influencing drainline carry?

Research Methodology: An online survey/questionnaire was emailed to plumbers in several states. Business email addresses were obtained using the Freedom of Information Act (FOIA) and with the cooperation of the California's Contractors State License Board (CSLB). It was critical to survey plumbers in California as the state laws for water conservation have been in place for the longest amount of time in the U.S. Plumbers answered questions regarding demographics, structure type, type of plumbing service, installation processes, layout, operating problems, and future drainline development goals and ideas. Most of the questions were objective in nature, but there were several questions where plumbers could give qualitative responses about drainlines to expand their answers.

Preliminary or Final Results: Of the objective questions, 105 to139 plumbers responded to each question. Plumbers across 16 states responded, with 70% of respondents coming from California, Virginia, and Maryland. Seventy percent of plumbers specialized in residential work and 65% specialized working in existing structures doing service/repair work or remodeling.

Plumbers encountered improper installation 25% of the time in existing structures. Primary causes for slow drains and stoppages were user behavior, i.e. wipes and towels (54%) and system failures (36%). Plumbers who noted "other" causes remarked that *tree roots* were a primary drainline issue. In remarking on 11 drainline system issues, sags and swales were the largest issues (69%), followed by tree roots (66%), incorrect slope (60%), and low-flow fixtures with plumbers suspecting this issue 43% of the time. Two-thirds of plumbers (and three-quarters in California) noticed that since the implementation of water conservation fixtures, there are more stoppages in existing drainlines and that it likely has an effect on drainline carry. Regarding drainline redesign, plumbers prioritized simplifying drainline installation and fitting connections, followed by increasing drainline flexibility, durability, and incorporating a lightweight solution.

Research Impact: This survey outlines and validates critical goals for designing future drainlines, specifically, easing installation in existing structures, and reducing bulky drainline components and connections that can result in improper slope. Additionally, water conservation has not addressed the back end of plumbing systems where drainline carry issues are becoming more problematic. At the same time, during these times of drought, tree roots seeking out water sources are becoming a growing issue as they infiltrate drainlines and cause plumbing back-ups.

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Incorporating Social Equity Considerations into Transportation Asset Management

Fawzi G. Khalife, S.M.ASCE, LEED AP,

Graduate Research Assistant, Dept. of Civil and Environmental Engineering, Colorado State Univ., Fort Collins, CO

Mehmet E. Ozbek, Ph.D., A.M.ASCE,

Professor and Joseph Phelps Endowed Chair, Dept. of Construction Management, Colorado State Univ.,

Fort Collins, CO

Rebecca Atadero, Ph.D., M.ASCE,

Associate Professor, Dept. of Civil and Environmental Engineering, Colorado State Univ.,

Fort Collins, CO

Erin E. Arneson, Ph.D., Aff.M.ASCE,

Assistant Professor, Dept. of Construction Management, Colorado State Univ.,

Fort Collins, CO

Recently, interest in social equity across many local, state, and national transit and transportation agencies has been triggered by events such as the COVID-19 pandemic (FTA 2021), as evidenced by the inaugural conference "Advancing Transportation Equity" which highlighted the need to recognize social equity objectives and measures in transportation plans and practices (TRB 2021). However, this interest in equity has not yet fully permeated into routine practices. For example, when looking at literature such as the FHWA definition of transportation asset management (TAM), there is still no mention of equity (FHWA 2021). What makes matters more complicated is the fact that equity is still hard to define and is lacking consensus among researchers and practitioners as to what it includes and how to incorporate it in transportation projects (ASCE 2021).

The objectives of this research study are to (1) identify key concepts in social equity as defined by academic literature, by the state of practice in local governments, and by members of community-based organizations, (2) inventory existing practices used to consider social equity in transportation related areas, and (3) establish a definition of social equity that fits the context of TAM decision making. The authors examine the literature that considers social equity in TAM decision making. Afterwards, the authors will interview local transportation agencies and distribute a survey to a broader set of agencies and organizations, helping with the collection of data about equity in transportation. Thematic qualitative analysis will then be used to analyze the data and findings.

By analyzing literature considering social equity in transportation plans and decision making practices, the authors noticed minimal incorporation of social equity objectives and measures. In the plans and rating systems studied, the authors observed that more attention and consideration was given to issues such as climate change and economics. This is translated into clear measures for these topics, such as carbon footprints for environmental analyses. However, the social aspect is still lacking clear definitions and measures in this context. This research will be informative to practitioners and researchers who are interested in studying ways transportation management can contribute to equity. Its findings will contribute to better incorporation of equity objectives into TAM practices.

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Drivers and Barriers of Horizontal Directional Drilling Adoption for Utility Construction

Chinedu Okonkwo, Ibukun Awolusi, Ph.D., and Jiannan Cai, Ph.D.

The University of Texas at San Antonio San Antonio, TX Kristopher Harbin, Ph.D. Texas A&M Transportation Institute College Station, TX

Installation of underground utilities with the conventional open-cut method is becoming more difficult as underground infrastructure gets more congested. Recent studies have shown that Horizontal Directional Drilling (HDD), a fastgrowing method of installing underground utilities, has demonstrated its ability as an economical and efficient alternative to the open-cut method. However, HDD is still lacking a broad adoption as a preferred method of underground utility installation which presents research need to identify the reason for this limited acceptance. This study presents an exploratory review of the factors influencing the application of HDD and a synthesis of the key drivers and barriers impacting HDD adoption. The aim of this study is to identify the factors driving the adoption of HDD, the risk associated with HDD application together with the obstacles hindering the widespread adoption of HDD for underground utility installation. The study also presents a review of the current state of the technology in the industry and identifies gaps and areas where further research could improve the adoption of HDD. An exploratory review is carried out to identify the current state of the technology, factors driving or impeding adoption and implementation for utility construction. The study is based on the review of electronic literature from ASCE, ScienceDirect, and Web of Science databases. Relevant materials from Google Scholar are also included in this study. Only articles directly related to HDD, Trenchless Technology construction, and open-cut construction are considered in this study. A two-step approach is used in obtaining relevant information from the materials by first reviewing the abstracts and conclusions to determine each article's relevance to the study before reviewing the entire article. A review of the current state of the technology, the different sectors of underground utility construction their levels of HDD adoption (HDD market size) is presented in this study. The risks associated with HDD as well as their possible causes are analyzed in detail. The study also presents a synthesis of the drivers and barriers to the widespread adoption of HDD. The findings of this study are expected to provide the necessary information needed in developing an explanatory framework that can be used by stakeholders in the utility construction community for enhancing the adoption and implementation of HDD. The scientific information obtained from this study will also be used to develop a real-time parametric artificial intelligence prediction model that could guide operation crew in taking proactive measures in risk management.

Poster Title: The COVID-19 Impact and Syndrome on the Architecture, Engineering, and Construction Industry

Mickey Chacon and Yupeng Luo, Ph.D.

California State University, Fresno Fresno, CA

Introduction/Problem Statement: The Covid-19 pandemic has presented unprecedented challenges to every part of our society on a global scale. Within a short period of time, it has left a strong and lasting impact on the architecture, engineering, and construction (AEC) industry in terms of safety precautions, productivity, project planning and delivery. The study intends to unveil and dissect how the industry has evolved and how certain aspects of the adaptation could be long lasting or temporary.

Research Objectives: The research focuses on the following questions:

1) what were the new safety precautions developed in response to the pandemic and how have they affected productivity in the office and on the job site?

2) how did the shelter-in-place order affect the delivery of projects under production and the planning of new projects? and

3) what is the foreseeable long-term impact on the AEC industry in a post-pandemic world?

Research Methodology: In a detailed literature review, this study will examine the various challenges the industry has encountered during the pandemic and compare the U.S. government and industry responses with those from other countries. Structured in-depth interviews with professionals from the AEC industry were also conducted to help further explore the research questions.

Preliminary or Final Results: Some preliminary findings include: During the pandemic, while some loss of business did occur, labor and material prices increased significantly, many projects experienced various delays, however, the AEC industry remained strong overall with a high demand in the market. Companies have either developed or adopted an efficient Covid-19 safety protocol. The interview revealed an increase in confidence to work remotely in the AEC industry. Many companies (especially architectural and engineering firms) plan to incorporate more work-at-home measures in a post-pandemic future. However many also agreed that they would still prefer the in-person format for training novice employees and interns.

Research Impact: The research investigates how the AEC industry has evolved since the pandemic and how certain aspects of the adaptation could be long lasting or temporary. This global phenomenon will be a major chapter in the development of new styles of architecture and advancement in HVAC and may provide a different work life for the upcoming generations of architects, contractors, subcontractors, and engineers.