Reflective Essay

[redacted]

Reporting Period: August 2015 - Present

I joined Michigan State University (MSU) in August 2015 as an Assistant Professor of Construction Management in the School of Planning, Design, and Construction (SPDC). I am also an Adjunct Assistant Professor in the Department of Civil and Environmental Engineering at MSU. My research focuses on *human-centered engineering and construction*, an intersection of construction management, human factors engineering, and building science. My research seeks data-driven solutions that integrate human factors information to the building construction system design and ergonomics for efficiency, safety, and sustainability. My research has been funded by major agencies including the National Science Foundation (NSF) and the Department of Transportation (DOT). I have published over 40 peer-reviewed papers in the area of architecture, engineering, and construction in which 28 were published (18 journal and 10 conference papers) after I joined MSU. I serve national academic committees including the Construction Industry Institute (CII) and the NSF review panel. I also serve as a reviewer for grant agencies, journals, and conferences. In 2016, I received the Best Journal Paper Award from the American Society of Civil Engineers (ASCE) for a paper published in the *Journal of Architectural Engineering*.

Prior to joining MSU, I was a postdoctoral fellow at Virginia Tech, School of Construction. The graduate studies and prior work experience at Virginia Tech prepared well me for my career. At that time, my research focused on sustainable housing technology which was sponsored by the Virginia Housing Development Authority. My research has identified benefits of housing policy to encourage energy efficiency in the affordable rental stock in Virginia. I collaborated with [redacted] and modeled a Resilience Built Environment framework for assessing housing market. I also participated in another project that analyzed the obstacles of green building innovations. The research won the best paper award by the American Real Estate Society for its contribution to the sustainable real estate. Through these experiences, I was able to observe the ways to integrate research, teaching, and service with a focus on sustainability.

MSU and SPDC's commitment to the improvement of sustainable built environment strongly aligned with my career agenda. Since then with the support of my school, colleges, and university, I was able to follow the career path I envisioned for myself. In the past two years, I have been active and productive in my research program, have continuously improved teaching, and provided service to school, university, and broader community. With the continuing alignment of my career goals with SPDC's vision, I believe I can continue to be a productive faculty member at MSU.

Career Goal

My vision is to build a program that successfully integrates research, teaching, and service. My ambitious career goal is to become a leader in the field of the sustainable built environment through advancing the sustainability of green buildings and infrastructure. My research agenda in the next 3-5 years focuses on the automated human behavior detection for energy efficiency improvement. The goal aligns well with SPDC's vision that is to "*create a sustainable built and natural environment that enriches communities, economic and family life*." My long-term research goal is to advance sustainable built-environment systems through integration of human factors and

artificial intelligence. Unlike research that intervenes in occupant behavior to achieve energy efficiency, my research aims to optimize green building technologies to fit the human. My educational research aims to foster a globally competitive STEM workforce in the green buildings and infrastructure for the 21st century. Unlike engineering educators who seek significant technical advances, my teaching will cultivate a systems philosophy that balances human-environmental interactions in a sociotechnical system. In reaching the goals, I will further enhance SPDC's partnerships with community colleges, local economic development, and the industry.

Research Program

My research is dedicated to understanding and applying human factors information to the building construction system design and ergonomics for efficiency, safety, and sustainability. By Google Scholar, my research has 9 High-Index publications which is higher than most of my peers. I seek data-driven solutions and decision-making to obtain balanced, optimal, and robust sociotechnical systems that include people, technology, organization, and environments. My methods include the construction engineering, human factors engineering, building science, machine learning, data mining, building information modeling (BIM), virtual reality (VR), augmented reality (AR), applied statistics, simulation and visualization, experimentation, field survey, and spatial analysis with geographic information systems (GIS). My research interests are instinctively motivated by a sense of responsibility to save lives and alleviate losses. The emerging trend of climate change inspires us to input effort to the climate adoption and disaster mitigation upon the built environment. Such effort is to save ourselves, our planet, and our offspring. Construction is recognized as a dangerous and complex industry, any contribution to the risk mitigation means saving. I see data science and information technology not a goal but excellent tools to reach goals.

Before joining MSU, my postdoc research includes sustainable housing, construction informatics, construction safety management, and risk/systems management. I have investigated, directed, or participated in ten funded research projects across U.S., Australia, and China. As a PI or Co-PI, my research was supported by multiple research grants including NSF, the Associated General Contractors of America (AGC), Housing Virginia, and Virginia Tech. I was active in compiling research proposals for external funding sources such as NSF, NIH, and other federal/state agencies. The research outcomes included two scholarly books and refereed publications in the built environment, including major ASCE journals. My publications were cited more than seventy times including the chief editor of *Automation in Construction*. I was invited by more than ten international journals for reviewing more than twenty scientific manuscripts.

After joining MSU, as a continuation of my postdoctoral research, I took part in a project funded by the NIH. In partnership with Virginia Tech and Purdue University, I developed two joint reports up to date and currently are working on a final report. I funded one Ph.D. student with this project and served a committee member for another Ph.D. student at Virginia Tech. Under my leadership, we produced more than four journal publications (with another three under review in top journals in our field) and published four conference papers with the Virginia Tech partners up to date. As a team, we widely disseminated our results to academia and industry. Most importantly, this project provided me the opportunity to verify the metrics I developed in my Ph.D. with nationwide big data analytics. Having led to an early recognition in our field for sustainable project delivery and to larger research projects, I believe this project is a steppingstone in my career.

I have conducted a multi-year longitudinal study that identified the interaction effects of building technology and occupant behavior on energy consumption. I analyzed building technical data and occupant behavioral data using 4 years of monthly energy use data (2013–2016) from over 300 households. Unlike previous research which isolated the effects of building technology or occupant behavior on energy consumption, my research has found energy consumption to be a joint effort. I have identified four significant occupant behavior activities that directly relate to energy consumption and two that indirectly relate to energy consumption. My research findings suggest that the most advanced technologies are not necessarily the optimal option for all households when pursuing energy use reduction. For example, a highly energy-efficient cooking range is not useful when occupants rarely cook at home. These interactions indicate the significance of my future research project and have created a baseline that I can use to further quantify and detect occupant behavior from energy consumption and ultimately optimize building technology.

In my research plan, I aim to achieve my career goals by providing an innovative method for occupant behavior detection centered on the advancement of sustainable built–environment systems by integrating human factors and artificial intelligence. A significant issue in advancing the sustainability of green buildings and infrastructure is the ability to integrate human data into green engineering. Under human factors engineering, the first design question in a human–building system after establishing an energy efficiency goal is to determine which functions to assign to the building and which to assign to the human. Designer and engineers should clearly understand the purpose and methods of occupants; however, this clarity is typically hard to determine because quantifiable occupant behavior data are difficult to obtain. Many follow-up projects will be proposed and conducted as an extension. I will conduct big data analytics with utility companies (e.g., Consumers Energy and DTE Energy) to obtain a deeper evidence-based understanding of the functions that should be assigned to occupants and to ultimately improve the energy efficiency and performance of green buildings and cities.

I and my research team have successfully applied advanced computing (e.g., big data, text mining, machine learning, and simulation) and human factors engineering (e.g., socio-technical systems design and macroergonomics analysis) techniques to engineering problem-solving. Research results from one of his studies that developed a resilient built-environment model examining a national residential building database of 2,580,000 homes. The study indicates that effective resilience management should protect from natural hazards and suggests a complementary relationship between resilience and sustainability, that is, sustainable systems without resilience are less likely to be adaptive. The study was awarded the "2016 Best Journal Paper" by the American Society of Civil Engineers (ASCE). My prior accomplishments in advanced computing ensure the success of the planned work in occupant behavior detection and integration.

My ongoing NSF grant ([redacted]) will advance knowledge of educational research for STEM students and other fields by providing instruments that assess the impacts of STEM education reform efforts and inform the instructional decisions of the faculty. As expected, intellectual infrastructure will be enhanced by developing instruments and a framework that can have a substantial impact on educational improvement efforts in STEM disciplines. To date, the team has developed the instruments and completed a pilot study. In summary, the total amount of external proposals I submitted accumulates over 3 million with personal award contribution of $46,911.

Teaching and Mentoring

I believe that an educator's mission is to open the door of knowledge for students and motivate them to approach the success in a self-directed manner. I believe effective learning environments at higher education institutions should foster students' problem-solving skills, utilize collaborative learning, and effectively integrate research and teaching. My teaching found current challenges in teaching and mentoring students on sustainability topics; thus, I seek solutions to effectively inspire students to engage and learn. I found that a building information modeling (BIM)-based learning environment help students develop collaborative skills. Using multivariate regression, I identified a significant difference in learning outcomes owing to peer effects and proposed a peer learning and review (PLR) setting. I further developed an Augmented Reality (AR) APP for his BIM class. Using pre-and-post analysis, I identified improved learning outcomes and learning enthusiasm. My NSF research project is developing an instrument for engineering faculty to improve their course delivery. Therefore, my passion and experiences in STEM education have prepared myself for the planned educational goals.

Before joining MSU, my years of education in construction prepared me to teach most construction management core courses including BIM, sustainable built environment, risk management, housing, building systems, construction estimating, scheduling and project management. I have taught BIM-related courses for undergraduate and graduate students at Virginia Tech for more than five years. I mentored undergraduate students in research symposia and competitions. I knew ACCE accreditation procedures and got trained on pedagogical design and curriculum development. My technical skills enabled me to teach online courses.

After joining MSU, I was continually looking for innovative ways to disseminate knowledge to a broader audience. In 2015, I redeveloped 90% of the course CMP328 – *Construction presentation graphics and BIM* for undergraduates. For the course, I drafted a new 120-page lab manual in teaching BIM, which had an international publisher (Taylor & Francis) interested in this manual becoming a textbook. In 2016, I developed a new course, CMP828: *Advanced Virtual Design and Construction (VDC)*, which has been approved by the university and became effective in 2017. I have developed VR and AR applications for my teaching, which attracted a large number of multidisciplinary students to enroll. BIM and VDC is an intelligent 3D model-based process involving digital representation of physical and functional characteristics of buildings and infrastructure. BIM represents the game-changing technology for the architectural, engineering, and construction (AEC) industry, which greatly increases productivity and gets widely implementation globally. For the educational purpose, BIM provides an ideal platform to simulate and analyze energy efficiency. In the future, I will integrate novel loop learning module to my previously developed modules, such as the multidisciplinary team-based learning (TBL) module and the BIM-based energy modeling and analysis (EMA) module. The course development and redevelopment are not easy; however, my SIRS scores show a quick good progress jumping from 2s to 1s in two years after joining MSU.

My particular emphasis has been on the impact of mentoring on the success of female and underrepresented minorities (URM) students. I am currently mentoring a female Ph.D. student and have graduated two male MS student and an African-American undergraduate student. I use my start-up funds to support them and mentors them to succeed. The female Ph.D. student, [redacted], has a strong interest in the research of building performance and she is very good at building technology. Yet she was struggling how to reduce building energy consumption since she found

the improvement is marginal. I incrementally guided her to think outside of the technology box and introduced her human factors as a possibility. She said, "*I never realized that we can think about the problem in this completely reverse way, and this is great*!" As a result, she has narrowed down her dissertation questions to focus on the interaction between occupant behavior and green building using machine learning approaches. In her second year (2017) at MSU, she has published two papers and presented them at ASCE's International Conference of Computing in Civil Engineering held in Seattle, WA; co-authored two journal papers with me (using machine learning technique); received the ESPP fellowship (university-level); earned her LEEP AP certification by the U.S. Green Building Council; and, more importantly, decided her career path to be a faculty member. I have graduated two MS students: [redacted] for Plan A Thesis and [redacted] for Plan B report. Their work aligns well in my research agenda and demonstrates value to advance sustainable infrastructure and construction automation.

Service

I believe that service within the university and the broader community is essential in becoming a scholar in our field. The service and outreach activities I was involved in the past two years are briefly explained below. I have been active in the national and international academic community.

I am a member of the ASCE, American Society of Engineering Education, U.S. Green Building Council, and International Council for Building. I served as a grant reviewer for NSF panels and Hong Kong Environmental Protection Department. I am a member of the Construction Industry Institute (CII)'s academic committee, the ASCE Committee of Data Analytics and Sensing, the ASCE Committee of Visual Information Modeling and Simulation, and the ASCE Construction Research Council. I have contributed to several journals and conference proceedings as a reviewer. The top journals in our field that I have been a regular reviewer for include: Journal of Construction Engineering and Management, Journal of Management in Engineering, and Energy and Buildings.

I have served to my school and university in the past two years on several committees such as the SPDC's Academic advisor search committee. I advised construction management students to attend Great Lakes Builders Show Career Fair. I attended the American Council for Construction Education (ACCE)'s annual meeting to prepare accreditation for our construction management program. I led students to attend the Student Contractor Awareness Night (SCAN) hosted by AGC of Michigan. On a regular basis, I regularly attended SPDC and CM faculty meetings; evaluated graduate applications for our CM program. I co-led the work on graduate recruitment improvements in our program via Masters and doctoral recruitment flyer (design and content) with Dr. Mollaoglu and via exposure and promotion to students in top Chinese universities.

Concluding Remarks

MSU is known for its innovative academic programs, recognized internationally as a top research university, and is a leader in international engagement. Since my arrival at MSU, with the help of my colleagues at SPDC, I am becoming a valuable faculty member with my efforts in research, teaching, and service within the university and broader community including international area. My career goals strongly align with the SPDC's vision for leading the integration of planning, design, and construction to create sustainable-built environments. I believe with my work in the past two years serving as a foundation for my career, I will continue to be a productive faculty member at MSU and become a recognized scholar in the field of sustainable built environment.