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Emerging technologies and the changing transportation workforce: Lessons in predicting the future

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Abstract

Transportation, as in every other sector, is being transformed continuously by emerging technologies that both create new efficiencies and opportunities and challenge current workers and workplaces to keep up with new knowledge and competencies. This article focuses on the lessons learned from the National Transportation Career Pathways Initiative and work of the National Network for the Transportation Workforce. The intent is to better understand and offer insights into predicting and substantiating the changing knowledge, skills, and abilities (KSAs) required of the workforce, and to inform changes in professional development and academic programs. Findings from this research demonstrate the challenges faced in preparing the future transportation workforce. This work also identifies strategies required to ensure that the next generation of transportation workers are both available and prepared to address these challenges in the years to come.

Introduction

The landscape of transportation is changing dramatically - not only in terms of the systems and infrastructure themselves, but also how these are operated and maintained. Tremendous shifts are occurring as new technologies automate various driving tasks and rideshare and new modes of transport emerge driven by the Internet of Things (i.e., e-scooters). Intelligent Transportation Systems (ITS)[1] are yet another example of a fundamental change in the way transportation systems are operated and managed. ITS are an integrated deployment of data and communications technologies coupled with sensing interfaces that provide real-time data for improving the safety and efficiency of transportation systems. As technology continues to evolve at a rapid pace, so do ITS applications, creating more advanced systems for managing mobility of people and goods. Within the context of Smart Cities,1 [2] (and particularly autonomous and connected vehicles and infrastructure), ITS plays a pivotal role. Thus, ensuring the transportation workforce is prepared to assess, deploy, and manage these systems is critical to the success of Smart City initiatives and our nation's future.

Examples of emerging technologies:

Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) wireless communications-based safety applications enable vehicles to inform a driver of roadway hazards and dangerous situations that they can't see.

Connected vehicle environmental applications can advise drivers on how to optimize their vehicle's operation and maintenance for maximum fuel efficiency.

Data from connected vehicle systems can also provide traffic management centers with detailed, real-time information on traffic flow, speeds, and other vehicle conditions. This can be used to optimize system operation.

1 Smart City development and ITS have been in process for decades but received a significant boost from the 2015 U.S. Department of Transportation Smart City Challenge.

There are significant challenges to adapting the workforce to these new technologies, modes, and systems that are disrupting the industry. Some challenges arise from continued misperceptions and general lack of awareness of existing transportation occupations. Other issues result from new KSA (Knowledge, Skills, and Ability) requirements for existing roles as well as new occupations emerging to address the changing way work is performed. Workforce planning has typically been conducted based upon examining historic trends. This approach, however, can lead to significant over or underestimation of occupational forecasts in this environment. It can also fail to identify evolving or emerging occupations that are being created. Transportation agencies and companies struggle to bring in new expertise, create new job categories covering emerging competencies and skills needed, and revise and upskill existing positions in a workforce system notoriously slow to change. This has resulted in workforce being recognized as one of the most important challenges facing the industry – across both the public and private sectors.[3, 4]

National Transportation Career Pathways Initiative

In recognition of these trends and issues, the Federal Highway Administration funded the National Transportation Career Pathways Initiative (NTCPI) to examine the impact of transformative technologies on the transportation workforce in five key focus areas: engineering, environment, operations, planning, and safety. This project was conducted by the five Regional Surface Transportation Centers that collectively form the National Network for the Transportation Workforce (NNTW),[5] with each center leading research in one of the five focus areas (Figure 1).

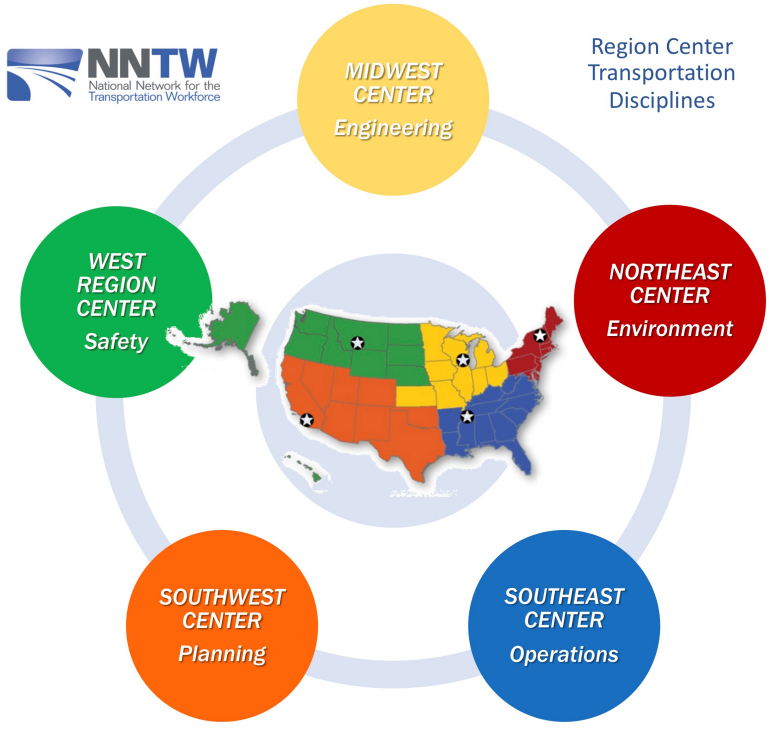

Figure 1: NNTW National Transportation Career Pathway Initiative

The results, building off regional Jobs Needs and Priorities Reports conducted by each center,[6] indicate that fundamental shifts are needed not only in how education and training programs are aligned across academia and industry, but also in how we evaluate trends and plan for the workforce of the future. The following sections examine the approach to

predicting KSAs, lessons learned, and implications for workforce development and academic programs, using examples from the operations and environment focus areas.

Predicting Workforce KSAs and Identifying Training Pathways

A cohesive approach was undertaken across the NNTW to developing deep insight into each NTCPI focus area related to priority occupations, key skillsets, primary challenges, and opportunities for innovation for the future transportation workforce. The traditional approach of reviewing occupation projections from the Bureau of Labor Statistics was combined with real-time labor market information (LMI), literature review, and stakeholder surveys and interviews to develop a comprehensive picture of how each area is expected to evolve. Stakeholders included public and private sector transportation professionals and post-secondary faculty in relevant transportation disciplines. This research informed development of a set of priority occupations and corresponding career pathways, job descriptions, programs of study, and experiential learning recommendations (see Figure 2 for one example).

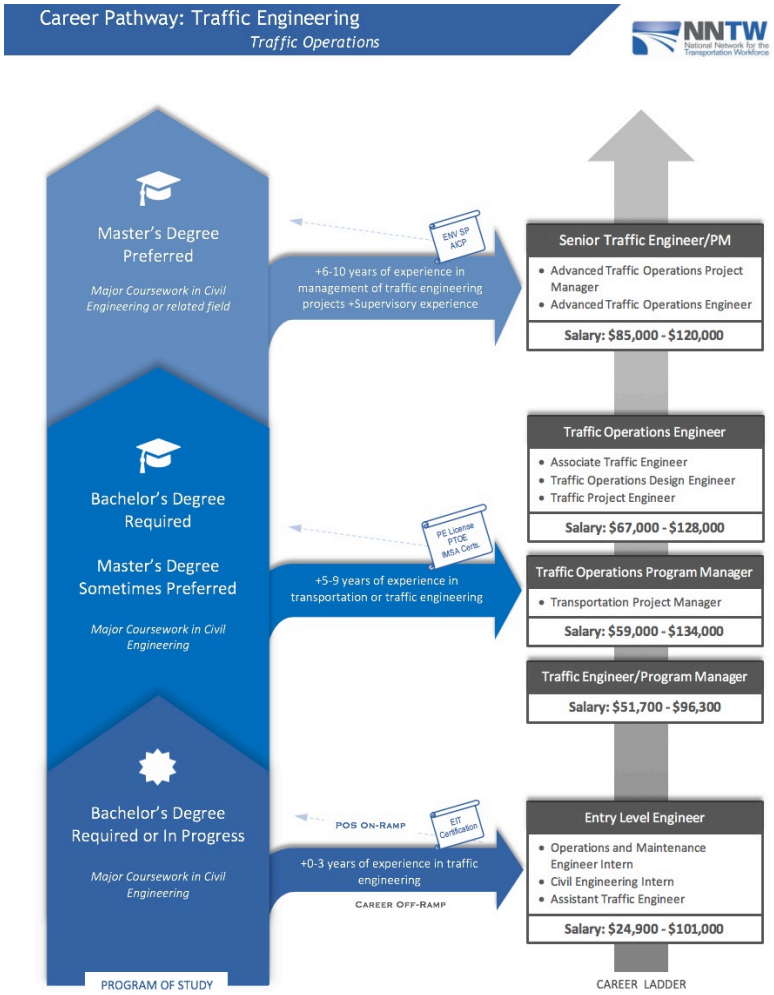

Figure 2: Sample Operations Career Pathway model with multiple entry/exit point, connecting to job specifications and opportunities.

The KSA requirements developed from this work highlighted the evolving nature of the transportation workforce. For example, within operations, interdisciplinary skillsets were identified as key to success for future professionals. Another set of required abilities included the need to be flexible, responsive, and adaptive to an ever-changing set of technological

tools and innovations. For environmental fields leading to transportation occupations, similar KSAs related to technology were identified. The most frequently-cited skill set employers emphasized for environmental occupations was communication, particularly because of the increased importance of interaction and collaboration (across varied roles within an organization as well as external stakeholders) in dealing with highly-technical aspects of ITS and other systems. This was closely followed by the ability to deal effectively with the public, ability to work on a team, ability to work independently, analytical skills, and working knowledge and experience with project management practices.

In terms of training pathways, operations occupations will continue to require significant on-the-job training because of the complex nature of the roles and the specialized terminology/ systems/ technologies employed within each. The most significant barrier identified is that of awareness - and the fact that there is no "formal" (or single) transportation operations career pathway. In fact, for many of the occupations, there are multiple programs of study that can provide career entry. This points to the need for more intentional development of project-based learning opportunities within varied disciplines that can lead to operations careers. Environmental occupations span a wide range of fields, from wildlife biology, to hydrology, to bicycle mobility system planning.[7, 8] The NTCPI project chose to focus on environmental work inherent in the rapid growth of ITS and deployment of Smart City technologies. Employment requires a fundamental set of field-specific competencies. Employers indicated that they expect students will seek out experiential learning opportunities prior to employment. Additionally, significant learning will be required in the early years of employment. This requires the building of more internal education and training programs, and/or external partnerships with educational institutions to meet the continuing learning needs of workers as their careers advance.

The research approach of the NTCPI project identified a comprehensive set of challenges to transportation workforce preparation. These challenges are indicative of the evolving transportation landscape and the complexities that arise from more technologically driven and highly interdisciplinary problems to be solved. For the transportation workforce of the future, we must address these challenges identified through the NTCPI project:

1. Bachelors/masters degrees are required for most job opportunities, but there are virtually no direct community college feeder programs, nor is transportation well established in K-12.
2. Skill sets and competencies needed for transportation are in high demand in other fields; it has been difficult to define transportation as a field of focus, or a career path of choice.
3. Academic programs remain in silos, while emerging fields and competencies require cross-disciplinary instruction and skills.
4. Limited employer internships, pre-graduation work experience in secondary and post-secondary education do not allow for the development of applied knowledge valued by employers.
5. New fields and career pathways are not captured by LMI, leaving specific occupations, skill sets, and needs with no traditional documentation that is the basis for most academic program decisions.
6. Needs of industry are developmental, not fixed, given the pace of technological change, making academic preparation problematic.
7. Well-established academic programs are resistant to needed interdisciplinary approaches. Curriculum is slow to keep pace with industry, and lacks cross-disciplinary focus.

Lessons Learned

The key to developing rich information related to each focus area was the combination of numerous sources - including historical trends, real-time LMI, input from professionals in both academia and industry, and the examination of literature and thought leadership from other industries. In the face of rapid technological evolution, there is no "one stop shop" for data relevant for workforce planning. Workforce planning is only going to become more complex as the development of new occupations accelerate due to technological innovations, whether due to the technologies themselves, policy implications, ethics, or other considerations.

One of the most significant disconnects for transportation workforce development is that of career awareness. In interviewing numerous stakeholders, very few were identified who purposefully set out on a transportation career path. Rather, they discovered or "fell into it" once they entered the job market, and had very little understanding of what they were getting into when they started. Importantly, stakeholders also noted that they wished that they had known in advance so that they were better able to prepare or so that they spent less time searching for the right career fit. In addition, the transportation field is generally profiled as a male-dominated field, focusing on construction and engineering, creating barriers to entry and retention for women, who are significantly under-represented across all modes and disciplines.[8] This means that it is critical to transportation workforce development to make transportation career pathways more visible and to develop strategies for attracting diversity to the industry.

It is also important to note the complexities arising from the rapid acceleration of technology and its impacts on how work is conducted in transportation. Academic institutions struggle to keep up with changing demands from industry, which can seem to be a moving target. Additionally, traditional academic silos do not bode well for the future, as increasingly we see demand for interdisciplinarity, both from the standpoint of how skillset requirements and fields are evolving and from the teams that must be assembled to solve complex challenges with ITS.

What does the future hold?

> "I believe that we are at an inflection point in the transportation arena that is as significant as when the engine replaced the horse and buggy. Today, the dramatic change underway is the merger of technology between the car, truck and other vehicles with the roadway. This will change the way we move goods, services and people on our roads and highways. In the future, I view data as the new asset that will dramatically enhance public safety, save lives on our roadways, improve mobility, enhance program and operational efficiency, and create jobs."
>
> - Carlos Braceras, President, AASHTO, before the Committee on Environment and Public Works of the United States Senate, November 28, 2018.[9]

For the transportation industry, it is clear that preparation of the transportation workforce of the future needs to focus on building a brand, starting early in the educational process, and being collaborative across modes and disciplines. Across all focus areas, lack of awareness of the transportation industry as a whole, lack of understanding of connections to STEM (Science, Technology, Engineering, and Math), and limited knowledge of the significance of transportation to our communities and global society is a barrier. Concerted efforts are needed to "brand" transportation and tell the story of the industry. This is important not only

for students considering career pathway options, but also for those influencing them (parents, teachers, guidance counselors, etc.).

Students often start fully developing career identities in high school, but make academic choices that may affect their ability to pursue particular pathways (i.e., those requiring advanced mathematics) in middle school. Students begin developing perceptions related to themselves and career "fit" (and particularly gender stereotypes) as early as elementary school. Efforts must begin very early in students' educational experiences to ensure they are aware of opportunities and do not close doors (whether figuratively or literally) before ever fully understanding and exploring transportation career possibilities. While the NTCPI focused on post-secondary education, career awareness efforts (including academia-industry partnerships) have to begin much earlier to truly make a difference in the pipeline. This needs to be the focus of future initiatives and cooperative program development between educational organizations and employers.

To develop a truly robust workforce it is imperative to work across academic silos and academia and industry must also work hand-in-hand. The incredible pace of change and the complexity and specialization across various components of the industry make it nearly impossible for any single academic program to fully prepare students for the work they will face. Rather, it is the role of academia to prepare students to be thought leaders and problem solvers, to expose students to varied real-world applications and experiences, and to help them develop the skillsets required to adapt to varying data, software platforms and technologies. Academia must become more dynamic, interdisciplinary, and experiential - and industry must help them get there.

Conclusion

In moving programs forward to address these barriers and achieve an increase in well-prepared and inspired applicants to the emerging fields and high priority occupations in transportation, the NTCPI project has recommended implementation strategies that should be of value in other fields as well. As the NNTW works with the FHWA to advance specific strategies it will emphasize specific program features and principles.

1. Purposeful partnerships between educational and training institutions and employers
2. Curriculum embedded with experiential learning
3. Purposeful integration of interdisciplinary content into curricular programs

Alignment with these principles will help ensure education systems evolve to keep pace with transformative technologies and their implications for the future of our workforce. The opportunities for the next generation of transportation workers to be attracted to the field and to come to it with appropriate KSAs is dependent on the development of a broad agreement and working relationship of many stakeholders. It is imperative that collaboration occur between educational and industry partners to move education and training, as well as the definition of occupations and work, forward in a way that keeps pace with the rapid changes in technologies and techniques that are redefining how people and things are moved.

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