SMART CITY AND THE MODEL OF VOCATIONAL EDUCATION AND TRAINING: NEW TRENDS, ADVANTAGES AND CHALLENGES

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Abstract: The article examines some of the trends, benefits and challenges of smart cities in the context of vocational training and education. Smart cities are transforming the urban environment with an emphasis on technology, sustainability and improved quality of life. This research aims to understand how these changes affect the skills needed by the workforce and how vocational education programs can adapt to meet these changing demands. Identification attitudes and opinions (including those of experts), how existing professional programs can be adapted in smart cities to include training in these new skill areas with a standardized survey, qualitative analysis.Transboundary pressing problems that professional education must solve to integrate into smart cities are analyzed. It is also emphasized on the essential role of professional education, as a leading pillar for the realization of smart cities, leading to the positive transformation for social progress. By integrating technology, education and urban development, smart cities can pave the way for a future where every individual can contribute to and benefit from the collective prosperity of the smart city. Joint efforts and a shared vision for inclusive progress will be instrumental in building a world where innovation and sustainability are at the heart of urban evolution, creating a legacy of empowerment and resilience for future generations. As smart cities continue to evolve, the integration of data-driven insights, citizen engagement and co-creation will play a central role in shaping the socio-economic landscape. Citizen participation, transparency in governance and the use of analytics will enable smart cities to make informed decisions that increase the efficiency, sustainability and inclusion of urban spaces.The journey towards inclusive and sustainable smart city development and vocational education integration is a multifaceted approach that emphasizes collaboration, innovation, data-driven decision-making and citizen engagement. Adapting to these new trends in education and urban development also requires a reevaluation of traditional teaching methods. Integrating technology into vocational education programs not only cultivates skills for the future, but also offers opportunities for personalized and accessible learning experiences. The main accent is set on what should be the characteristics of vocational education that could fit with the tendencies of the intelligent city environments and be congruent with the future trends.. By embracing these pillars and maintaining an environment of continuous learning and adaptation, smart cities can position themselves as centers of opportunity and progress, where technology serves as a catalyst for positive transformation and societal progress.
Keywords: smart city, VET, integration, trend.

1. INTRODUCTION

The term "smart city" itself first appeared in news reports in the 1990s [1], describing cities that use new technology systems to improve services and infrastructure. The first project and the first smart city is Amsterdam (*De Digital Stad in Amsterdam* 1994)[2] . This project, translated as „Digital City", is often cited as the first major smart city initiative to provide free internet access and improve communication between citizens and the government. The late 1990s and early 2000s saw a growing emphasis on using technology to address environmental challenges and improve resilience in urban areas. There were initiatives by IBM and Cisco in the mid-2000s , with these tech giants launching separate smart city projects in 2005, further bringing the concept to the Internet. Rapid technological progress and the rise of Big Data , cloud computing , the Internet of Things (IoT) and artificial intelligence (AI) are driving the development of more sophisticated solutions for smart cities (*Montes 2020*) Smart cities have become a major area of focus for governments and businesses around the world, with significant investments in infrastructure, technology and research.

A strictly technically defined „smart city" is the fruit of cybernetics and the desire for intelligent urbanism. The idea is purely theoretical to create so-called „*digital twins"*— „a virtual replica of a city that consists of a digital representation of city networks" [2] . , in order to accumulate all data sets of input variables and accordingly develop algorithms for sustainable, ecological, efficient ergonomic and other solutions, which in practice has already become an increasingly common feature of smart urban plans of many cities.

Smart cities and technical and vocational education and training have become interconnected in recent years, creating new trends, demonstrating strengths and posing challenges for both fields (*Aurigi, 2022*). More than ever, the emergence of the knowledge economy and global economic competition are forcing governments to prioritize the quality of education, lifelong learning and the provision of equal opportunities for all. The integration of AI and digital technologies into the education system has significantly improved the capabilities of Technical Vocational

Education and Training (TVET) programs, enabling more personalized and accessible learning experiences (*Ojha et al., 2023*) . These technological advances have also contributed to the development of smart cities, which include smart infrastructure, sustainable practices and efficient services. However, the rapid pace of technological progress also brings challenges for TPO O and smart cities. The challenge for TVET is to keep pace with evolving industry requirements and ensure that skills training remains relevant and „future proof ".

TVET programs must adapt and align their curricula with rapidly changing industry demands, while smart cities must effectively manage the vast amount of data generated and ensure equitable access to technology and educational opportunities for all citizens.

In the context of smart cities, challenges include effectively managing and integrating data from different systems, ensuring data security and privacy, and ensuring equal access to technology and educational opportunities for all citizens in order to create inclusive and sustainable smart cities.

Integrating technology into TVET programs and smart cities presents both new opportunities and challenges. On the one hand, the use of artificial intelligence and digital technologies in TVET programs has enabled more personalized and accessible learning experiences (*Ojha et al. 2023)*, helping people acquire relevant skills for the changing labor market. In the context of smart cities, technology integration leads to challenges such as managing and integrating vast amounts of data, ensuring data security and privacy, and providing equal access to technology and educational opportunities for all citizens. *(Ahad et al., 2020)* In addition, digitization and the ralicity of the divide between developed and developing countries presents a significant challenge in integrating technology into TVET programs and smart cities. (*Habibi et al. 2023; Mpungose 2020*). Other challenges include keeping up with rapidly evolving industry demands (*Felice & Petrillo 2021*), managing and integrating data from different systems, ensuring data security and privacy, and ensuring equitable access to technology and educational opportunities for all citizens (*Alphonso 2023*) . The growing prevalence of mass online courses, online learning and blended learning has brought new challenges to educational institutions. Furthermore, integrating technology into smart cities requires managing and integrating vast amounts of data, ensuring data security and privacy, and ensuring equal access to technology and educational opportunities for all citizens. However , this has been followed by challenges such as providing access to reliable electricity and high-speed internet in developing countries and dealing with the loss of control over certain parts of the learning process. (Smith *2023*) To address these challenges and use the full potential of technology in TVET programs and smart cities, it is essential for policymakers and educational institutions to invest in infrastructure and resources that support reliable electricity and high-speed Internet access, provide technical support for teachers and students and develop strategies for effective analysis and use of educational data to improve learning outcomes.

New trends in the development of smart cities and TVET

It is essential in these trends to understand their implications for the future of education and urban development. The integration of AI and digital technologies into TVET programs is revolutionizing the way people acquire skills and knowledge. Personalized instruction and accessible learning experiences have become more common, catering to different learning styles and needs. However, challenges remain, particularly in terms of ensuring the continued relevance and adequacy of skills training in the face of rapidly evolving industry demands. As industries embrace automation and digitization, it becomes imperative for TVET programs to adapt their curricula and training methodologies to meet these changes. The need to cultivate forward-looking skills that align with the demands of the digital age is paramount.

Similarly , the development of smart cities depends on the effective integration of technologies. Although the vast amount of data generated by various systems and devices provides opportunities for improved urban management, it also poses challenges in terms of:

- ✓ data security,
- ✓ privacy and equitable access to technology and
- ✓ educational opportunities for all citizens.

Additionally, the emergence of massive online courses, blended learning, and AI-driven educational platforms has transformed traditional educational institutions. This has led to new challenges that institutions must address to ensure the successful integration of these technologies. The need for reliable electricity and high-bandwidth internet in developing countries and dealing with the loss of control over certain parts of the learning process are vital aspects to consider.

- Integrating Technology into TVET Programs to Design *Future* -Oriented Skills.
- Bridging *the digital divide* and ensuring equitable access to technology and educational opportunities.
- Collaboration among stakeholders, including public-private partnerships, to develop robust digital literacy infrastructure and programs.

- Mass adoption of online learning platforms, blended learning and AI-driven educational tools to improve the effectiveness and efficiency of TVET programmes .
- Using data analytics and educational data to inform decision -making and improve learning outcomes in TVET.
- Provision of technical support and training for educators on effective use of technology in TVET programs.

Their strengths are :

1. Access to a wide range of educational resources and content through online platforms (*Brouwer et al., 2017*) .
2. Flexibility of learning opportunities for students , allowing them to learn at their own pace and in their preferred location
3. Improved connectivity and communication through technologies enabling collaboration and knowledge sharing across borders
4. Efficiency and cost-effectiveness, as online learning reduces the need for physical infrastructure and enables scalability
5. Personalized learning experiences tailored to the individual needs of learners.

Challenges are**:**

1. Integrating and implementing technology in TVET programs can require significant investment in infrastructure and resources (*Bhati et al. 2023*) .
2. Resistance to change and lack of technological skills among teachers and learners (*Brouwer et al., 2017)* .
3. The need for ongoing technical support and training for educators to use technology effectively.
4. Good financial security for implementation of digital projects.

Adapting to these new trends in education and urban development also requires a reevaluation of traditional teaching methods. Integrating technology into TVET programs not only cultivates skills for the future, but also offers opportunities for personalized and accessible learning experiences. However, it is essential to address the challenges that come with implementing these changes.

Bridging the digital divide and ensuring equitable access to technology and educational opportunities remains a significant obstacle to creating inclusive and sustainable smart cities. Collaboration between stakeholders, including public-private partnerships, is critical to developing robust digital literacy infrastructure and programs. This partnership can facilitate the equitable distribution of resources and ensure that no part of the population is left behind in the digital age. Managing the shift to a less centralized learning process and addressing the need for reliable electricity and high-speed internet in developing countries are critical priorities. Policymakers and educational institutions must invest in infrastructure, provide technical support, and develop strategies for effective use of educational data.

The idea of a need for change in education and urban development, especially in the context of technological integration, provides opportunities to revolutionize the learning experience and urban governance. By addressing the challenges and harnessing the full potential of technology, we can pave the way for inclusive and sustainable smart cities and future-oriented TVET programmes.

Finding a culture of innovation and adaptability

In the pursuit of inclusive and sustainable smart city development, fostering a culture of innovation and adaptability is paramount. The idea of continuous improvement and openness to emerging technologies can pave the way for the successful integration of innovative solutions in urban management and educational practices.

Encouraging experimentation and entrepreneurial spirit in the community can lead to the emergence of creative solutions to local challenges, ultimately contributing to the overall sustainability and dynamism of the smart urban environment. Furthermore, fostering a culture of lifelong learning and skills development can ensure that people are prepared to adapt to technological advances and contribute to the innovation ecosystem in a meaningful way.

By fostering an environment where creativity and innovation thrive, smart cities can harness the collective ingenuity of their residents to tackle complex urban problems and drive sustainable development. This cultural shift towards understanding change and understanding new ideas will be instrumental in shaping a future where smart city development and the integration of TVET are synonymous with progress and prosperity for all.

The role of data in the development of a smart city

In addition to fostering innovation and collaboration, the integration of data and analytics plays a key role in driving the sustainable and inclusive development of smart cities. By leveraging data-driven insights, urban planners and decision-makers can make informed choices that increase the efficiency, sustainability and inclusion of urban spaces.

Using a wide range of data sources, including sensors, IoT devices and citizen feedback, enables the creation of a comprehensive understanding of urban dynamics. This data-driven approach enables city governments to optimize resource allocation, transportation networks, and public services, ultimately improving the quality of life for all residents.

2. MATERIALS AND METHODS

Research question

How do smart city initiatives impact the skills and training needed for vocational education programs?

Smart cities are transforming the urban environment with an emphasis on technology, sustainability and improved quality of life. This research aims to understand how these changes affect the skills needed by the workforce and how vocational education programs can adapt to meet these changing demands.

Identification attitudes and opinions (including those of experts), how existing professional programs can be adapted in smart cities to include training in these new skill areas with a standardized survey, qualitative analysis.

3. RESULTS

Study Findings: Impact of Smart Cities on Vocational Education Needs. Summarized in ***Table.1*.**

Target audience 40 people, of which :

- Professional teachers (50%)
- Industry professionals in fields related to smart cities (30%)
- City officials involved in smart city development (20%)

Survey Questions: (multiple answers possible)

1. How do you think smart city initiatives will affect the skills needed for future jobs in your city/region?
    - Increased demand for data analytics skills (85%)
    - Need for cybersecurity and data privacy training (75%)
    - Increase in jobs related to *Internet of Things* (**IoT**) support (65%)
    - Growing demand for expertise in renewable energy technologies (70%)
    - Other (please specify) (15%) - Answers include skills in urban farming, autonomous vehicle support and smart grid management.
2. How well do you think existing vocational education programs in your area prepare people for the skills needed in smart cities?
    - Very well prepared: 5%
    - Somewhat prepared: 35%
    - Not well prepared: 50%
    - Not sure: 10%
3. What are the biggest challenges in adapting vocational education programs to the needs of smart cities?
    - Lack of funding and resources for technology integration (7 0 %)
    - Need for continuing professional development of professional teachers (6 5 %)
    - Difficulty keeping curriculum current with rapidly changing technology (60%)
    - Challenges in collaboration between academics and industry (45%)
    - Other (please specify) (1 5 %) - Responses included difficulties in attracting students to new programs and limited access to real learning facilities.
4. What are some potential solutions to address these challenges? (open)
    - Increased government funding for vocational education programs (most common response)
    - Public-private partnerships between educational institutions and industry (general response)
    - Developing flexible, modular training programs (general response)
    - Investment in online learning platforms and skills development simulations (general response)
    - They focus on fostering a culture of lifelong learning (mentioned by several respondents)
    - Please share any additional comments or suggestions regarding the impact of smart cities on vocational education: (Open)

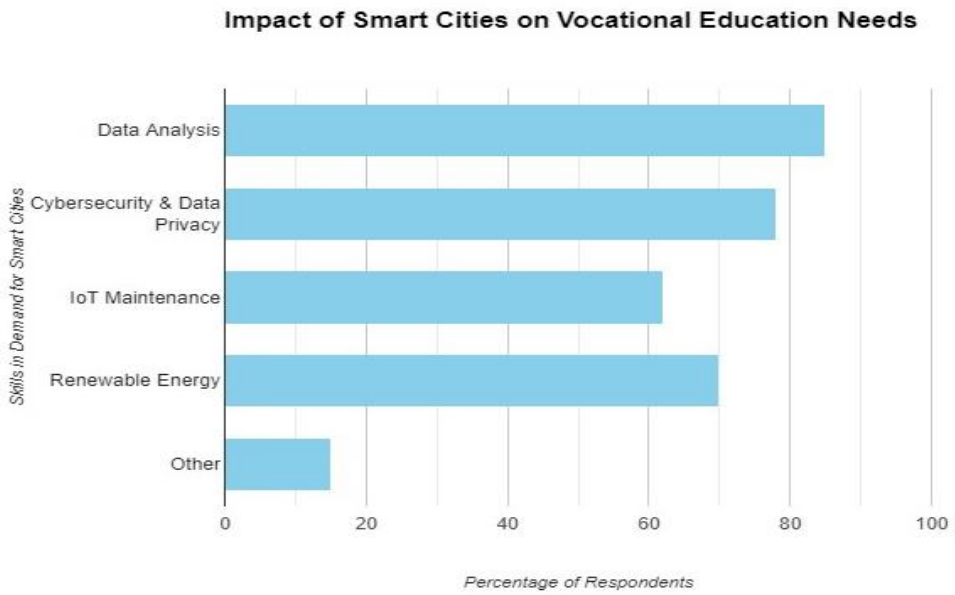
Table 1. Summary of survey results

CLAIMS (OPINION)	PERCENTAGES
INCREASED DEMAND FOR DATA ANALYSIS SKILLS	85%
CYBERSECURITY AND DATA PRIVACY TRAINING NEED	75%
IOT SUPPORT JOBS GROWTH	52%
GROWING DEMAND FOR RENEWABLE ENERGY SKILLS	70%
OTHER SKILLS MENTIONED	15%
EXISTING PROGRAMS PREPARE SMART CITY SKILLS	
* VERY WELL PREPARED	5%
* SOMEWHAT PREPARED	35%
* NOT WELL PREPARED	50%
* UNCERTAIN	10%
CHALLENGES IN ADAPTATION OF PROGRAMS	
* LACK OF TECHNOLOGY FUNDING/RESOURCES	70%
* NEED FOR PROFESSIONAL DEVELOPMENT OF TEACHERS	65%
* DIFFICULTY IN KEEPING CURRICULUM CURRENT	60%
* CHALLENGES FOR COLLABORATION (TEACHERS AND INDUSTR	45%
* OTHER CHALLENGES MENTIONED	15%

Source: *author's research.*

Several respondents emphasized the importance of *including soft skills* such as *communication, teamwork and critical thinking* in vocational programs alongside technical skills.
Some industry professionals have emphasized the need for professional education to focus on specific certifications related to smart city technologies.
Several educators expressed concern about potential job displacement due to automation and the need for retraining programs.
Overall, survey results suggest a strong belief that smart cities will significantly impact the skill set needed for future jobs, shown resumed in **Fig.1**. While there are challenges in adapting vocational education, there is a clear need for collaboration and investment to ensure that graduates are prepared for these new opportunities.

Fig.1. Impact of a smart city on VET.



Source: *author's research.*

4. DISCUSSIONS

Apositely and relevantly might be set the *questions for future research and analysis* on the topic in the aspect of:

1. Exploring the potential for new professional programs focused on emerging smart city technologies such as smart grid management, autonomous vehicle support or urban agriculture.

2. Exploring the role of technology in vocational education, such as using online learning platforms, simulations or virtual reality for training in specific skills relevant to smart cities.
3. Exploring collaboration between professional institutions, businesses and city governments in developing and implementing training programs that meet the needs of smart cities.

Presumed Expected results might be:

- ✓ Identifying specific skills and knowledge needed to work in smart cities.
- ✓ Recommendations for curriculum changes or new vocational programs to address skills shortages.
- ✓ A review of best practices for integrating smart city technologies into professional education.
- ✓ An analysis of the importance of stakeholder collaboration in preparing the workforce for the future of smart cities.

5. CONCLUSIONS

In conclusion, may be posit that the journey towards inclusive and sustainable smart city development and TVET integration involves a multi-pronged approach that emphasizes collaboration, innovation, data-driven decision-making and citizen engagement. By embracing these pillars and maintaining an environment of continuous learning and adaptation, smart cities can position themselves as centers of opportunity and progress, where technology serves as a catalyst for positive transformation and societal progress. The integration of technology, education and urban development has the potential to uplift communities, bridge existing divides and cultivate a future where every individual can contribute to and benefit from the collective prosperity of the smart city. Through collective efforts and a shared vision for inclusive progress, we can build a world where innovation and sustainability are at the heart of urban evolution, creating a legacy of empowerment and resilience for future generations.

Digital transformation and sustainability must ensure interaction and integration between new physical and digital technologies to drive continuous improvement in different fields (*Felice & Petrillo, 2021*). By integrating technology, education and urban development, smart cities can pave the way for a future where every individual can contribute to and benefit from the collective prosperity of the smart city. Joint efforts and a shared vision for inclusive progress will be instrumental in building a world where innovation and sustainability are at the heart of urban evolution, creating a legacy of empowerment and resilience for future generations. As smart cities continue to evolve, the integration of data-driven insights, citizen engagement and co-creation will play a central role in shaping the socio-economic landscape. Citizen participation, transparency in governance and the use of analytics will enable smart cities to make informed decisions that increase the efficiency, sustainability and inclusion of urban spaces.

NOTES:

1. https://www.verdict.co.uk/smart-cities-and-their-state-of-play-today/
2. https://will-brown.medium.com/the-origins-of-the-smart-city-85acfd5b7715

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