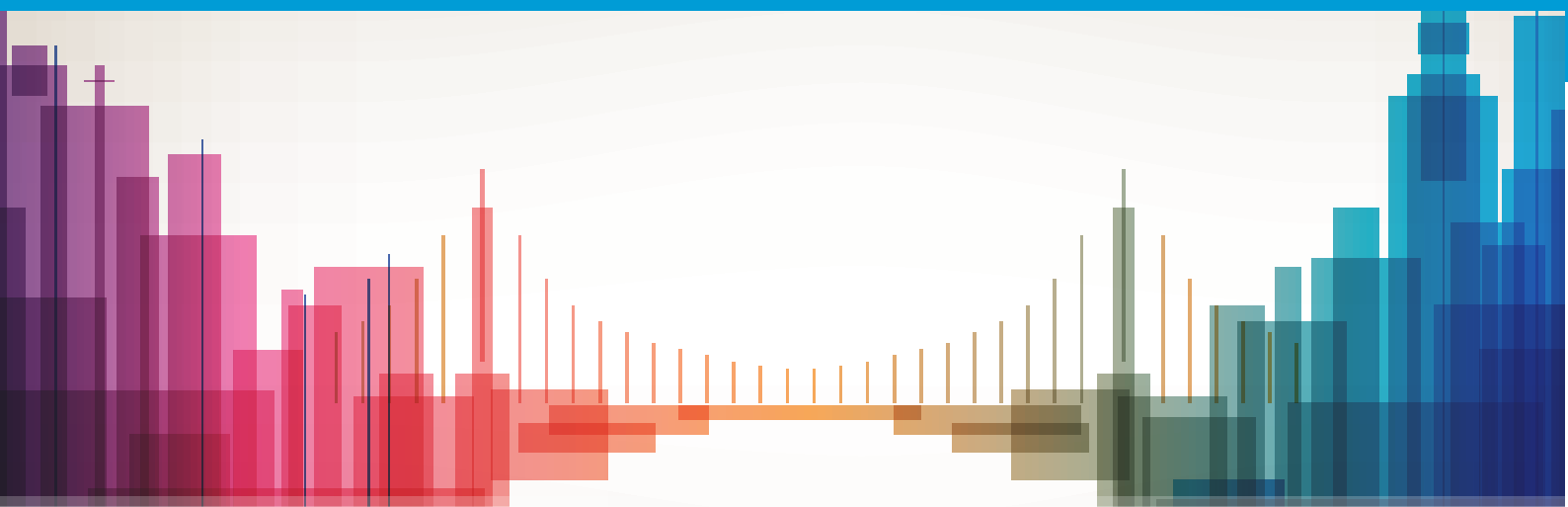


Jeddah, Saudi Arabia

Case study of the U4SSC Guide to Digital Wellbeing







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Foreword

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Disclaimer

The opinions expressed in this publication are those of the authors and do not necessarily represent the views of their respective organizations or U4SSC members. In line with the U4SSC principles, this report does not promote the adoption and use of Smart City technology. It advocates for policies encouraging responsible use of information and communications technologies (ICTs) that contribute to the economic, environmental and social sustainability as well as the advancement of the 2030 Agenda for Sustainable Development and the Pact for the Future and its Global Digital Compact.

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Abbreviations and acronyms

Abbreviation	Full Form
AI	Artificial intelligence
GDPR	The General Data Protection Regulation
ICT	Information and communication technologies
IoT	Internet of Things
KPI	Key performance indicators
LMS	Learning management systems
OT	Operational Technology
PDPL	Saudi national privacy laws
PPP	Public-private partnership

1 Introduction

Jeddah Central is a new Jeddah waterfront downtown that draws its inspiration from the great city of Jeddah and its unique historic centre. The project responsibly rehabilitates brownfield urban land and returns public life to the Red Sea. It will be the foremost waterfront destination in Jeddah, tied into the North Corniche, and an integral part of the wider city and its waterfront. It is inspired by urbanism and the historic fabric of Al-Balad (Old Jeddah), while responding in a contemporary manner by utilizing environmentally sustainable and smart approaches to creating a new urban centre. It aims to promote culture and entertainment, enhance a healthy lifestyle, and wellbeing, preserve natural resources and national heritage, promote circularity, reduce pollution, optimize energy and water usage, and be designed to be resilient against future climate changes.



The combination of new technology, innovative design, and enlightened public policy will empower Jeddah Central as a high-performance, connected and vibrant community. The Smart City Strategy for Jeddah Central aims to make it a world-class development by integrating leading smart and sustainable technologies in different sectors, including economy, living, society, mobility, environment and governance. By the Kingdom's Vision 2030 and its objectives, the Jeddah Central community will offer a unique experience to the public and a discernible journey for guests, while embracing Jeddah's heritage and identity.



2 Background & context

The guiding principles of Jeddah Central align with Saudi Arabia's smart city framework, as well as international standards. Jeddah Central relies on information and communication technology (ICT) to increase efficiency and improve the quality of urban services and citizens' wellbeing. These guiding principles need to be flexible to be able to identify new opportunities and ideas as digital technologies evolve. The aims of this framework can be summarized through this set of key objectives of a smart city, as detailed below.

Making Jeddah Central liveable when it enhances the quality of life for its citizens through the provision of digital healthcare services and the establishment of a technology-based education system. Focusing on sustainability involves promoting a sustainable environment and economy by adopting smart energy and water management programmes to reduce carbon and gas emissions, implementing smart waste management, and introducing smart transportation solutions. To ensure a secure environment for citizens, cybersecurity measures should be in place to ensure data safety. Additionally, the implementation of a smart video surveillance system on roads can contribute to the city's safety and traffic management. Internet of Things (IoT) deployment for fire and public service solutions also enhances security. To maintain services after unexpected incidents and warn against natural catastrophes using smart sensors, while building smart and resilient structures can help withstand the impact of climate change. To improve transparency and departmental coordination, an open data platform can be implemented for better data sharing. Data and analytics should be used to facilitate better decision-making processes.

The Human Experience is the most important key performance indicators (KPI) for any organization. Adding comfort is an easy way to improve wellbeing, make people more satisfied and productive, and create spaces that are responsive, optimized, efficient and so on. Real-time data are collected from online databases, Operational Technology (OT) systems, and IoT sensors. These data are then analysed on the integration platform and compared with reference values, and the results are displayed on the dashboards and heat maps and used to make data-driven decisions. This will allow the operator to pinpoint areas that need attention and to proactively improve the wellbeing and comfort of residents, employees and visitors.

Sensor readings, and any additional suitable data sources (such as time schedules), are used to generate qualitative alarms and role-based insights to users if the measured metrics exceed their static or dynamic setpoints. Predefined cleaning and maintenance schedules of functional spaces and utilities will be adjusted using measured data, and dynamically optimized in response to actual demand and space conditions. Unnecessary labor shall be minimized, and overall health and wellbeing maintained. Compliance with pandemic safety measures shall be quantified and alarms and role-based insights shall be generated to users if the measured metrics exceed their set-points. The digital twin solution allows for the integration of similar safety measures as the baseline target.



3 Digital wellbeing intervention / initiative

A digital wellbeing initiative adopted by Jeddah Central revolves around improving citizens' quality of life through the thoughtful integration of technology, data and services. Here are some key initiatives implemented:

- **Citizen engagement platforms:** Jeddah Central has developed digital platforms that allow citizens to participate directly in decision-making processes. These platforms offer real-time feedback on city services, enabling individuals to report issues, suggest improvements and vote on community projects.
- **Smart healthcare systems:** This initiative includes a comprehensive digital health ecosystem. Using mobile apps and wearable technology, citizens can monitor their health, access telemedicine services, and share health data with professionals in real time, so promoting preventive care and personal wellbeing.
- **Smart education systems:** This initiative in Jeddah Central Smart City focuses on personalized learning using artificial intelligence (AI) and data analytics to tailor learning paths to individual students' needs. It reduces stress, promotes mental wellbeing, integrates access to mental health support, and incorporates gamification to make learning engaging. Smart analytics track students' engagement and stress levels and help teachers intervene early with personalized support.
- **Digital wellbeing apps:** Jeddah Central has created an app that focuses on mental and physical health. For instance, a "Wellbeing Index", where residents can measure various aspects of their life quality, including mental health and job satisfaction, through an integrated app system. The city uses this data to improve social services.
- **Smart mobility solutions:** Jeddah Central adopted advanced smart mobility solutions that promote environmental sustainability and physical health. Bicycle-sharing schemes, pedestrian-friendly zones, mobility electrification, and public transport and logistics apps help reduce traffic congestion, decrease pollution, and encourage physical activity, all contributing to better wellbeing.
- **Smart environment monitoring:** Jeddah Central's agenda aims to enhance the quality of life by monitoring environmental factors like air quality and noise pollution. Smart sensors across the city collect data that feeds into a digital platform, which citizens can access to plan their activities based on environmental conditions, fostering physical and mental wellbeing.

These initiatives show how smart cities are leveraging technology to create more liveable, healthy, and inclusive environments for their residents.



4 Implementation of the digital wellbeing intervention / initiative

Implementing a digital wellbeing initiative within Jeddah's Central smart city such as a smart education system, involves a structured approach through multiple phases. The timeline can vary depending on the size and complexity of the city, but typically follows these key stages:

- **Planning and assessment phase (3-6 months):** This phase involves discussions with government agencies, schools, healthcare providers, and technology vendors to align on objectives. Analyse existing education and wellbeing challenges, gather input from teachers, students, and parents, and evaluate technological readiness. Determine technical, financial, and legal feasibility for the smart education system. Include considerations for digital inclusion, ensuring equal access to all students. Identify funding sources (public, private, or Public-Private Partnership) and allocate resources for the initiative.
- **Design and development phase (6-12 months):** This phase includes the definition of system architecture, including platforms for personalized learning, digital wellbeing services, and data analytics. Ensure the system complies with data privacy and security regulations. Work with educators to integrate wellbeing programmes (e.g., mindfulness training, and mental health resources) into the curriculum. Develop or procure digital platforms, including learning management systems (LMS), gamified learning tools, and telehealth services. Ensure the system is user-friendly for students and educators alike.
- **Pilot testing and training phase (6-9 months):** This phase involves the implementation of the system in a small group of schools or neighbourhoods. Test the platform's performance, collect feedback, and measure its impact on learning outcomes and student wellbeing. Provide comprehensive training to teachers, school administrators, and healthcare professionals on how to use the platform effectively. Gather feedback from students, teachers, and parents during the pilot, and make necessary adjustments to the system.
- **Full-scale implementation phase (12-18 months):** This phase includes expanding the digital wellbeing initiative to all schools across the smart city, ensuring sufficient infrastructure (Wi-Fi, devices, cloud services). Continue providing support and training for teachers, students, and administrators as the system scales. Launch campaigns to raise awareness among students, parents, and the community about the digital wellbeing initiative and its benefits.
- **Monitoring and optimization phase (Ongoing):** Use data analytics to monitor the system's performance, and track student engagement, learning outcomes and overall wellbeing. Use insights to continuously improve the education platform and the wellbeing initiatives. Based on feedback and emerging technology, continuously improve the system, adding new features such as AI-driven tutoring or new wellbeing programmes. Conduct annual reviews to assess the initiative's success in improving student learning and wellbeing.

In total, implementing a smart education system as part of a digital wellbeing initiative can take two to three years from initial planning to full-scale deployment, with continuous improvements afterwards.



The implementation of a smart education system as part of a digital wellbeing initiative in Jeddah Central can present several challenges. Here are some common challenges and the strategies designed to address them:

- **Digital divide and accessibility:** Not all students have equal access to digital devices or reliable Internet. This digital divide can exacerbate inequalities in education and wellbeing. Therefore, city admin, in collaboration with the city municipality and private sector, and Telco service providers provided subsidies for devices and Internet access for low-income families, and established free Wi-Fi zones in public areas, libraries and community centres. Schools also provided device loan programmes to ensure students have access to tablets or laptops.
- **Data privacy and security:** Collecting personal data, including health information, can raise concerns about data privacy and security, especially in education systems dealing with minors. Therefore, city admin must ensure compliance with international standards such as the General Data Protection Regulation (GDPR) or Saudi national privacy laws (PDPL). City admin used encryption to protect sensitive information and anonymize student data where possible, communicated how data would be used, stored and protected, and gave students and parents control over their data.
- **Teacher resistance and skill gaps:** Teachers may resist using new technologies due to a lack of digital skills or concerns about increased workload. Therefore, city admin was engaged in offering ongoing professional development to teachers on using smart tools and integrating them into their teaching methods. They also encouraged collaboration among teachers through mentorship programmes, where more tech-savvy educators guided those with less experience to ensure that the technology platforms are intuitive and user-friendly, minimizing complexity and time consumption for teachers.
- **Curriculum misalignment:** Integrating digital tools into traditional curricula can be challenging, particularly if the tools do not align with existing educational goals or standards. Therefore, city admin involved teachers and educational experts in the design and implementation of the smart education curriculum to ensure alignment with local educational standards. Gradually introduced new technologies, allowing educators to adapt content and teaching practices over time.
- **Financial constraints:** Implementing a smart education system can be expensive, particularly in terms of technology infrastructure, software, and ongoing maintenance. Therefore, city admin was collaborating with the private tech sector through public-private partnership (PPP) agreements to share the costs of developing and maintaining the system. In addition, they secured funding from national or international programmes focused on digital transformation or education. They launched small pilot projects that can be scaled over time as more resources become available is advisable.
- **Over-reliance on technology:** There is a risk that over-reliance on digital tools may lead to reduced interpersonal interaction, contributing to social isolation or screen fatigue among students. Therefore, city admin implemented a mix of digital and in-person learning, ensuring that technology supplements rather than replaces human interaction. They encouraged active



learning methods that engage students offline such as group projects, physical activities and outdoor education. Additionally, they encouraged the use of built-in tools to monitor and limit screen time, promoting healthy digital habits as part of the digital wellbeing initiative.

- **Technological infrastructure and maintenance:** The success of a smart education system relies on a strong technological infrastructure, which can be challenging to maintain and scale as the system grows. To address this, city admin considered using cloud-based platforms that are more scalable and require less physical infrastructure. It's important to schedule regular maintenance and updates to keep the platform running smoothly and securely. Additionally, they worked closely with technology providers to ensure proper technical support and infrastructure management.
- **Measuring impact and success:** Tracking the success of the smart education system in terms of academic performance and wellbeing can be difficult without proper evaluation mechanisms. Therefore, city admin used real-time data analytics to track student engagement, performance, and wellbeing, collected feedback from students, teachers, and parents to evaluate the impact of the initiative and make necessary adjustments, and conducted longitudinal studies to assess how the smart education system affects long-term educational outcomes and overall student wellbeing.

By addressing these challenges systematically, Jeddah Central ensures the successful implementation of smart education systems that not only improve academic performance but also enhance the overall wellbeing of students.

5 Results and outcomes

The success of digital wellbeing in Jeddah Central such as a smart education system, can be measured through a combination of outcomes and key performance indicators (KPIs). These metrics should capture improvements in educational performance and the wellbeing of students and citizens.

- **Improved academic performance:** This will be validated against enhanced student engagement and performance due to personalized learning experiences. Better academic outcomes such as improved grades, test scores, and graduation rates.

KPI01: Student performance data: Increase in standardized test scores, pass rates, and overall grades.

KPI02: Dropout rate: Decrease in dropout rates due to more flexible and adaptive learning environments.

KPI03: Completion rate: Percentage of students who complete assigned learning modules or courses within the given timeframe.



- **Enhanced student wellbeing:** This can be illustrated by increased access to mental health resources, reducing stress and anxiety among students. Improved balance between academic workload and wellbeing due to better time management and wellbeing-focused curriculum integration.
 - KPI04: Mental health service utilization:** Number of students using telehealth or counselling services provided via the smart education system.
 - KPI05: Student wellbeing surveys:** Increase in self-reported wellbeing metrics from surveys measuring stress, anxiety, and life satisfaction.
 - KPI06: Engagement with wellbeing programmes:** Participation rate in mindfulness, physical activity, and wellbeing-related courses or modules.
- **Increased access and digital inclusion:** Reducing the digital divide by providing equitable access to education and wellbeing resources for all students, regardless of socio-economic status. Greater educational inclusivity for students with disabilities or in underserved areas.
 - KPI07: Device and Internet access:** Percentage of students with access to required digital devices and reliable Internet connections.
 - KPI08: Participation of underserved students:** Increase in engagement from students in low-income or rural areas.
 - KPI09: Special needs accommodations:** Percentage of students with disabilities successfully using the platform's accessibility features (e.g., text-to-speech, high-contrast interfaces).
- **Higher Teacher and parental engagement:** More proactive engagement from teachers and parents through digital tools that track student progress and wellbeing. Teachers are better equipped to identify and address students' emotional and educational needs through real-time data.
 - KPI10: Teacher feedback:** Improvement in teacher satisfaction and ease of use with digital platforms, measured through surveys.
 - KPI11: Parent involvement:** Increase in the number of parents actively engaging with digital platforms to track their children's academic and emotional progress.
 - KPI12: Professional development hours:** Hours of teacher training completed on using the digital education system.
- **Optimized learning environment:** More personalized learning environments that adapt to each student's learning style and pace, improving retention and comprehension. Increased flexibility for students to balance academic workload with personal wellbeing activities.
 - KPI13: Adaptive learning progress:** Percentage of students benefiting from personalized learning paths and their rate of improvement over time.
 - KPI14: Learning module completion rates:** Time spent completing learning activities versus preset benchmarks for each grade level.



KPI15: Student satisfaction with learning environment: Feedback from students on the ease and personalization of their learning experience.

- **Reduced screen time and balanced digital engagement:** Managed and healthy screen time through integrated tools that monitor and regulate usage, reducing the risks of digital fatigue. Encouragement of offline learning and physical activity as part of the digital wellbeing programme.

KPI16: Screen time reports: Percentage of students adhering to recommended screen time limits.

KPI17: Physical activity engagement: Number of students participating in offline activities integrated into the education system such as physical education or mindfulness exercises.

KPI18: Break compliance: The frequency of students taking breaks as per system prompts for healthy digital use habits.

- **Data-driven decision-making:** Real-time data enables educational institutions and city administrators to make informed decisions, leading to more responsive and effective improvements in educational content and wellbeing support. Use of predictive analytics to identify students at risk of mental health issues or academic decline.

KPI19: Student data insights: Percentage of interventions made based on data analytics insights (e.g., flagging students for mental health support).

KPI20: Response time: Average time taken by teachers or support staff to respond to student wellbeing alerts.

KPI21: Predictive accuracy: The accuracy of predictive models in identifying at-risk students and providing timely interventions.

- **Community-wide wellbeing improvement:** Digital wellbeing extends beyond schools, improving overall community health through city-wide smart interventions that promote mental and physical wellbeing. Higher happiness and satisfaction levels across different demographic groups due to the integration of wellbeing into everyday digital experiences.

KPI22: City-wide wellbeing surveys: Improved scores on happiness and wellbeing indices among students and their families.

KPI23: Utilization of public wellbeing resources: Increase in the usage of community wellbeing tools such as public mental health apps or physical activity monitoring tools provided by the smart city.

KPI24: Public awareness and engagement: Participation rate in city-wide digital wellbeing initiatives such as public campaigns on mental health, physical fitness and digital balance.

- **Long-term learning and wellbeing outcomes:** Improvement in long-term student outcomes such as academic success, emotional intelligence, and resilience, which are crucial for personal and professional growth. Increased community resilience to challenges such as mental health issues, due to early intervention and a culture of wellbeing.

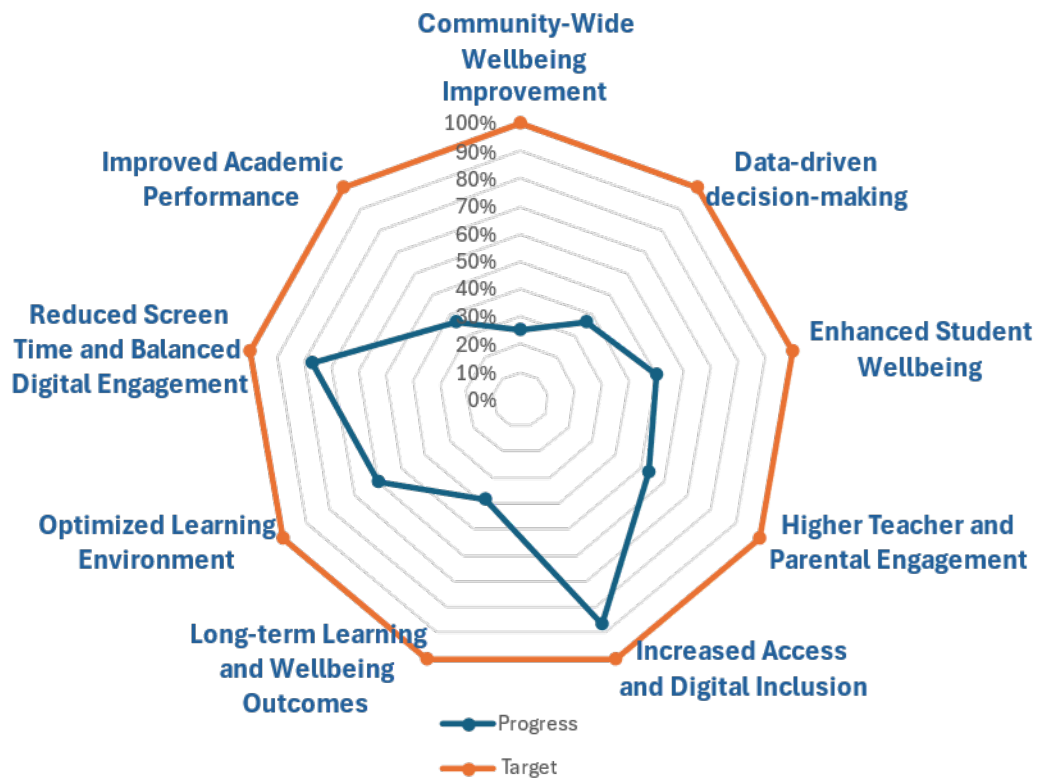
KPI25: Higher education enrolments: Percentage of students pursuing higher education as a result of improved academic outcomes.

KPI26: Career readiness: Feedback from students on their perceived readiness for future careers, measuring digital literacy, problem-solving, and emotional resilience.

KPI27: Longitudinal wellbeing studies: Long-term improvements in wellbeing, tracked over several years to measure the initiative’s lasting impact.

Figure 1: Jeddah Central Development Smart Education Radar

Jeddah Central Smart Education Maturity Radar



Source: Jeddah Central Development

By focusing on the outcomes and KPIs, smart cities can ensure that their digital wellbeing initiatives are effectively supporting the academic success and overall wellbeing of their residents. However, in general, the impact of a digital wellbeing initiative in Jeddah Central can be transformative, benefitting individuals and the broader community. Key impacts include:



Improved public health: By leveraging data analytics, AI, and IoT, city admin can monitor environmental conditions, air quality, and public health trends, contributing to healthier lifestyles and environments. For instance, apps can encourage physical activity and mental health support through personalized recommendations.

Increased digital inclusion: Digital wellbeing initiatives aim to bridge the digital divide by providing equal access to technology and digital literacy programmes. This ensures that all citizens, regardless of socio-economic status, can participate in the digital economy and access essential services.

Enhanced quality of life: Smart cities can use technology to reduce stress factors like traffic congestion, air pollution and energy waste. This leads to smoother daily operations and higher quality of life for residents, with less time spent on tedious activities such as commuting or navigating public services.

Community engagement and social connectedness: Smart technologies allow for more seamless communication between citizens and local authorities, fostering greater transparency, participation and collaboration. This strengthens the sense of community, supports mental health, and promotes social inclusion.

Personalized city services: Using big data and AI, smart cities can tailor services to meet individual needs, offering customized health care, education, and public service experiences. This level of customization contributes to an overall sense of wellbeing and satisfaction among city residents.

Sustainability and wellbeing: A focus on sustainability in a smart city contributes to long-term wellbeing by ensuring that resources such as water, energy, and waste management are efficiently managed. This reduces the environmental footprint and supports the mental and physical health of the population.

Data privacy and security: A robust digital wellbeing strategy emphasizes the protection of citizen data, fostering trust between residents and local governments. Clear policies on data use ensure that technology supports wellbeing without infringing on privacy rights.

6 Assessment of the Digital Wellbeing Intervention / Initiative

A digital wellbeing assessment framework is a tool for evaluating the effectiveness of digital wellbeing interventions and initiatives in smart cities such as the smart education system in Jeddah Central. This framework encompasses various dimensions of digital health, education and technology integration to measure the impact on individual and community wellbeing. However, like any framework, it has limitations and opportunities for enhancement.



Key components of a Digital Wellbeing Assessment Framework:

Health and wellbeing indicators

Physical health metrics: Track physical activity, sleep quality, and screen time to measure the physical effects of digital tools.

Mental health metrics: Measure stress levels, anxiety, and overall mental health through surveys and digital tools like telehealth platforms.

Engagement with wellbeing programmes: Analyse the extent to which users engage with mental and physical health resources provided by the digital wellbeing initiative.

Educational outcomes

Academic performance: Measure improvements in student performance such as test scores, completion rates, and personalized learning progress.

Digital literacy: Assess the improvement in digital literacy, focusing on how well students can use digital tools effectively and responsibly.

Learning environment impact: Gauge the balance between digital learning and offline activities, monitoring how students adapt to technology-rich learning environments.

User experience and satisfaction

Student and teacher feedback: Collect qualitative feedback on how digital platforms influence daily routines, productivity and emotional wellbeing.

User Satisfaction Surveys: Evaluate the overall satisfaction of students, parents and educators with the digital tools and platforms used in the education system.

Technology and infrastructure performance

System usability: Assess how intuitive and user-friendly the digital education platform is, including its interface, accessibility and responsiveness.

Data security and privacy compliance: Ensure data collection adheres to privacy laws and security best practices, protecting student and citizen data.

Technology uptake: Measure how widely and effectively the technological infrastructure (e.g., Internet, devices) is being utilized.



Equity and inclusion

Digital access: Assess whether students from all socio-economic backgrounds have equitable access to the digital tools and services provided.

Inclusion of vulnerable groups: Measure the participation and success of students with disabilities or those from underserved communities.

Digital inclusion initiatives: Monitor the effectiveness of efforts to bridge the digital divide (e.g., device loan programmes, free Wi-Fi zones).

Long-term impact and sustainability

Wellbeing over time: Track long-term improvements in physical and mental health, beyond initial adoption phases.

Career and lifelong learning readiness: Assess whether students are better prepared for future careers in a digital world and are developing lifelong learning habits.

Environmental impact: Evaluate the sustainability of the digital infrastructure in terms of energy consumption and waste reduction.

Figure 2: Digital Wellbeing Assessment Framework



Source: Khatib & Alami, Lebanon

7 Limitations & potential enhancements of the Digital Wellbeing Assessment Framework

Data collection challenges: It can be difficult to gather consistent and reliable data across diverse populations, especially in regions with limited digital access. Also, collecting detailed wellbeing data raises privacy concerns, particularly when dealing with sensitive health or emotional wellbeing metrics. Surveys used to assess mental and physical wellbeing are often self-reported, which can lead to inaccuracies due to subjective interpretations or social desirability bias.

Technological barriers: In areas with limited access to digital devices or reliable Internet, assessments may not accurately reflect the entire population's wellbeing. Older users, students with disabilities, or those with lower digital literacy may struggle with using digital platforms, skewing data or hindering participation.



Short-term focus: Many frameworks focus on short-term outcomes (e.g., engagement metrics) without considering the long-term effects on digital wellbeing such as career readiness or life satisfaction over several years.

Lack of flexibility: Frameworks may not adapt quickly to technological advancements or societal changes, limiting their relevance over time.

Cultural and contextual variations: One-size-fits-all approach: Assessment frameworks may not consider cultural, economic, or regional differences, making them less applicable in diverse environments. Some wellbeing indicators might not capture the nuanced challenges of specific communities or demographic groups such as the needs of rural versus urban students.

Complexity of wellbeing measurement: Emotional and mental wellbeing are inherently subjective and multifaceted, making them harder to measure through standardized tools. Wellbeing is influenced by a complex web of factors, including family life, social interactions and community support, which are not always captured in a digital wellbeing framework.

While the potential enhancements to the framework are:

Enhanced data collection and privacy solutions: Integrate more passive, non-invasive data collection methods (e.g., wearables) to reduce reliance on self-reported data and improve accuracy. Use blockchain technology for secure, decentralized data storage and processing, ensuring that sensitive wellbeing data remains private and tamper-proof. Utilize artificial intelligence to analyse data in real-time and provide instant feedback to students and educators on their wellbeing, academic progress, or mental health status.

Personalized assessments: Create assessment tools that adapt based on demographic factors such as age, location or socio-economic background, providing more contextually relevant insights. Design metrics that account for cultural variations in education and wellbeing, ensuring that frameworks are inclusive and applicable across diverse populations.

Focus on long-term wellbeing outcomes: Incorporate longitudinal studies to track the long-term effects of digital wellbeing interventions, including academic performance, mental health, and career readiness. Add sustainability metrics that evaluate the environmental and long-term societal impact of digital wellbeing initiatives (e.g., reduced digital waste, energy-efficient platforms).

Cross-sector integration: Broaden the framework to include social, economic and community wellbeing indicators, assessing the broader impact of smart city interventions beyond education alone. Integrate wellbeing with other smart city initiatives such as urban mobility, health care and environmental sustainability, creating a cohesive ecosystem for digital wellbeing.

Gamified feedback and engagement: Gamification of wellbeing: Introduce gamified feedback systems that engage students and citizens by rewarding positive digital behaviour and promoting



active participation in wellbeing activities. Create dashboards that give personalized, visual insights into individual and community wellbeing, helping students and teachers track progress in real-time.

Improved access and inclusion strategies: Focus on mobile-first designs that cater to underserved populations who may have more access to smartphones than computers or tablets. Leverage public-private partnerships to enhance funding for digital infrastructure and reduce the digital divide, ensuring all populations have access to the necessary tools for digital wellbeing.

By addressing its limitations and incorporating these enhancements, a digital wellbeing assessment framework can become more adaptable, inclusive, and effective in creating sustainable, long-term improvements in the lives of citizens.

8 Conclusion

The Jeddah Central Smart City project offers valuable lessons in digital wellbeing as part of its broader smart city development. Here are key insights drawn from the initiative:

Human-centric design: Jeddah Central's approach involves developing public spaces and infrastructure to improve mental and physical health. For instance, smart parks and recreational areas are equipped with technology that monitors air quality, temperature and crowd density to enhance comfort and promote healthier lifestyles. Therefore, technology should focus on enhancing the quality of life for residents, not just efficiency or convenience.

Data-driven wellness programmes: Health data analytics in Jeddah Central helps identify health trends among residents. Data from wearable devices, smart healthcare systems, and mobile apps is analysed to shape public health initiatives, leading to more personalized and preventive health care. Therefore, utilizing data insights allows for proactive interventions and customized public health solutions, improving overall community wellbeing.

Public engagement and digital literacy: Jeddah Central has been working to raise digital literacy through community outreach programmes. These initiatives educate residents on how to safely and effectively use digital platforms for health monitoring, access to services, and participation in the city's digital governance. Therefore, for digital wellbeing to be meaningful, the public needs to understand and feel comfortable using smart technology.

Inclusive smart services: Jeddah Central ensures that digital wellbeing services such as health monitoring, smart transportation and emergency services, are accessible to all, including the elderly and those with disabilities. Assistive technologies and universal design principles are integrated into the city's infrastructure. Therefore, accessibility and inclusion are vital to the success of digital wellbeing initiatives, as they prevent any section of society from being left behind.



Sustainability and wellbeing: In Jeddah Central, environmental monitoring systems track pollution levels, which helps inform urban planning and public health efforts. By maintaining a focus on sustainability, the city also improves air quality and green spaces, directly impacting residents' physical and mental health. Therefore, sustainable city planning, and environmental health directly contribute to digital wellbeing, as they address key factors that affect residents' health.

Resilient healthcare systems: The COVID-19 pandemic accelerated the implementation of telemedicine and remote healthcare services in Jeddah Central, showing the importance of flexible and resilient digital health systems. Digital platforms connected patients with healthcare providers, reducing the strain on physical health infrastructure during the crisis. Therefore, flexible digital health solutions provide critical support in times of crisis, ensuring continuous access to health care.

Smart mobility for mental wellbeing: Jeddah Central employs smart traffic management and intelligent public transportation systems that reduce travel time and traffic congestion, contributing to reduced stress levels for residents. Therefore, efficient mobility solutions not only improve urban efficiency but also contribute to citizens' mental wellbeing by reducing travel-related stress.

Cross-sector collaboration: The Jeddah Central project brings together technology firms, healthcare providers, urban planners, and government agencies to design integrated solutions. For instance, health data sharing between hospitals, local clinics, and smart city infrastructure allows for more efficient and holistic healthcare services. Therefore, digital wellbeing is a multidisciplinary effort that benefits from the combined expertise of the public, private, and academic sectors. The critical success factors for digital wellbeing in Jeddah Central Smart City can be categorized into several key areas. These factors have contributed to the success of the initiative by ensuring a balanced integration of technology, public health, and enhancements to quality of life.

- By focusing on improving the everyday lives of its citizens, Jeddah Central designed services that address specific challenges like public health, mental wellbeing, safety and convenience. Public spaces, healthcare services, and smart infrastructure were all built with citizen satisfaction in mind.
- Access to accurate, real-time data enabled the city to make informed decisions on everything from public health interventions to traffic management. This data-driven approach allowed for timely responses to challenges and continuous improvement of services.
- The seamless integration of systems like health care, transportation and public safety ensured that services functioned holistically. Centralized digital platforms for managing smart city services enabled efficient resource allocation and system interoperability.
- Public-private partnerships ensured that the latest innovations were brought to the project and that there was adequate funding, expertise and technology available. These partnerships also helped accelerate implementation and brought in best practices from the private sector.
- Successful digital wellbeing initiatives require that citizens understand and utilize the services provided. Jeddah Central focused on building public trust through educational campaigns, workshops and transparent communication about how data is used and protected.



- As the needs of the city evolve and new challenges arise, scalable systems allow Jeddah Central to expand services and adapt to new technologies. The flexibility of systems also ensured that they could respond effectively to unexpected situations such as the COVID-19 pandemic.
- Digital wellbeing in Jeddah Central wasn't just about technological convenience but also about creating a sustainable urban ecosystem. By integrating environmental monitoring, green spaces, and smart energy management systems, the project promoted healthier living environments while reducing the city's carbon footprint.
- Building resilient and secure digital infrastructures was key to gaining public trust and ensuring uninterrupted services. With increasing reliance on digital platforms for health care, transportation, and emergency response, the city focused on cybersecurity measures and backup systems.
- A clear vision for digital wellbeing, led by effective governance structures, ensured that projects were coordinated, budgeted, and implemented according to plan. Strong leadership helped overcome bureaucratic hurdles and enabled cross-sector collaboration.
- The success of Jeddah Central's digital wellbeing efforts was partly due to their focus on inclusivity. Digital services were designed to be accessible to people with disabilities, the elderly and underserved communities, ensuring that no one was left behind.

These critical success factors – centred around a citizen-first approach, integrated technology, and resilient systems – have played a vital role in shaping Jeddah Central as a model for successful smart city and digital wellbeing initiatives.

While Jeddah Central Smart City has achieved significant progress, several challenges lie ahead as the city continues to evolve its digital wellbeing and smart infrastructure initiatives. These challenges need to be addressed to ensure long-term success and sustainability:

Data privacy and security: As digital services expand, protecting sensitive data, particularly health, personal, and financial information, becomes increasingly critical. Failure to ensure robust data privacy and security measures could erode public trust in digital services and expose the city to cybersecurity threats.

Interoperability and integration of systems: Ensuring that different digital systems and platforms can work seamlessly. Without efficient integration, systems may become siloed, leading to inefficiencies, duplication of efforts, and less effective management of city services.

Digital inclusion and equity: Ensuring that all residents can access digital services, regardless of socio-economic background, age or ability. A lack of inclusivity could leave marginalized groups behind, creating social inequality and undermining the goals of digital wellbeing.

Scalability of infrastructure: Expanding smart city infrastructure sustainably and efficiently as the population grows. Failing to scale infrastructure adequately may lead to bottlenecks, service interruptions, and a diminished quality of life for residents.



Cybersecurity threats: Mitigating the increasing risks of cyberattacks on critical urban infrastructure. A successful cyberattack could disrupt essential services, compromise citizen data, and undermine trust in smart city technologies.

Public engagement and trust: Maintaining high levels of public trust and engagement with digital wellbeing initiatives. A lack of trust in digital initiatives could result in low adoption rates, reduced citizen engagement and, ultimately, failure to achieve the desired outcomes of the smart city project.

Environmental sustainability: Balancing urban growth and digital expansion with sustainability goals. Unsustainable growth could lead to environmental degradation, reduced air and water quality, and increased carbon emissions, negatively affecting public health and wellbeing.

Financial viability and investment: Securing ongoing financial resources and investment to support long-term smart city development. Insufficient or poorly managed funding could lead to stalled projects, underdeveloped infrastructure, or a lack of innovation in digital services.

Rapid technological change: Keeping up with fast-paced technological advancements. Falling behind in adopting new technologies could make the city's infrastructure outdated or inefficient, while prematurely adopting unproven technologies could result in wasted resources.

Policy and regulatory frameworks: Developing effective policies and regulatory frameworks to govern smart city operations. Inadequate regulatory frameworks could lead to legal, ethical and security issues, as well as slow down innovation and service delivery.

Resilience to natural disasters and crises: Building resilience against natural disasters, pandemics, and other crises. A lack of resilience could lead to widespread disruptions, undermining the city's capacity to ensure digital wellbeing and security in times of crisis.

Complex stakeholder coordination: Challenge: Coordinating across multiple stakeholders, including government entities, private companies and residents. Misalignment between stakeholders can lead to delays, inefficiencies and conflicts, which may hinder the successful implementation of digital wellbeing initiatives.

Addressing these challenges will require ongoing innovation, strategic planning, stakeholder engagement and flexibility to ensure that the smart city vision for Jeddah Central can be realized sustainably and inclusively.

The transferability of digital wellbeing and smart city innovations from Jeddah Central to other cities depends on several factors. While many of the core concepts are adaptable, successful implementation elsewhere requires thoughtful consideration of local contexts, resources, and challenges. Here are some key points regarding its transferability:



Scalability of technology: The technology infrastructure used in Jeddah Central such as IoT networks, smart health care, and environmental monitoring systems, can be scaled and adapted for cities of varying sizes. Smaller cities may focus on essential services first (e.g., traffic management or energy efficiency), while larger cities could adopt more comprehensive systems, including smart health care and environmental monitoring.

Customizing to local needs and culture: The human-centric and citizen-focused approach to smart city development in Jeddah Central can be replicated in other cities. Every city has unique social, cultural, and economic dynamics, and these must be considered when designing smart city services. What works in Jeddah may not fully translate to cities with different climates, economic structures, or societal values.

Public-private partnerships: The success of Jeddah Central is partly due to strong PPPs, which are key for financing, innovation, and scaling smart city initiatives. Cities looking to replicate Jeddah's model will need to develop robust partnerships with private companies, especially in technology, infrastructure, and service delivery. However, the local economic and political environment can influence the nature and success of these partnerships.

Governance and policy adaptation: The governance model used in Jeddah Central, including its strong leadership and collaborative cross-sector planning, can be applied to other cities. The success of smart city initiatives often depends on efficient governance and regulatory frameworks that support innovation, data security, and public trust. Cities with less mature governance structures may need to build capacity and improve coordination across government agencies to implement similar projects.

Data-driven decision-making: The emphasis on using real-time data for decision-making and resource optimization in Jeddah Central is highly transferable. However, the availability of data and the capacity to analyse and use it effectively varies across cities. Cities with lower digital infrastructure may need to invest in data collection tools (e.g., sensors, and analytics platforms) and build human capital in data analysis and management.

Sustainability and environmental focus: Jeddah Central's focus on sustainability through smart energy management, environmental monitoring, and green urban planning can be adopted by other cities. Different cities face distinct environmental challenges such as air pollution, water scarcity or energy inefficiency. Local solutions need to be tailored to address these specific environmental concerns, while maintaining sustainability goals.

Digital literacy and citizen engagement: The focus on building digital literacy and engaging citizens in the use of smart services is universally applicable. The level of digital literacy and access to technology varies significantly across cities and regions. In cities where there is a digital divide or lower tech penetration, digital literacy programmes must be prioritized to ensure equitable access to smart city services.



Infrastructure readiness: The backbone infrastructure that supports Jeddah Central's smart city framework – high-speed fiber optics, 5G networks, and smart sensors – can be transferred to other cities. The level of infrastructure development in each city is a major determinant of how easily Jeddah Central's solutions can be implemented. In cities with less developed digital infrastructure, significant upfront investment in telecommunications and IoT networks may be required.

Financial and economic factors: The economic benefits of smart cities such as job creation, efficient resource management, and improved public services, are transferable. Cities need to ensure they have the financial resources and economic stability to fund large-scale smart city initiatives. Public funding, PPPs, and international investments are critical, but the economic context of a city will shape how feasible and sustainable these projects are.

Legal and regulatory frameworks: Establishing clear legal and regulatory frameworks to govern data usage, privacy, and digital services is necessary for any smart city. The regulatory environment varies greatly between cities and countries, and adapting Jeddah Central's approach to data privacy, cybersecurity, and public governance will depend on local laws and governance structures.

Resilience to local conditions: Jeddah Central's resilience planning, including smart disaster management and flexible digital services, is a model for other cities. Resilience planning needs to be adapted to local environmental, social and political conditions. Cities prone to natural disasters, for example, might focus more on integrating smart disaster recovery systems, while others may prioritize economic resilience.

Long-term vision and leadership: The long-term vision for Jeddah Central, driven by leadership with a clear strategic direction, applies to any city aiming to implement smart city solutions. The level of political will and leadership commitment is critical. Cities with less stable political environments or frequent leadership changes may struggle to implement a cohesive long-term strategy for smart city development.

While the digital wellbeing and smart city initiatives from Jeddah Central are highly transferable, the success of such transfers depends on local adaptations, infrastructure readiness, governance, and the socio-economic context of the target city. Each city must tailor the principles of Jeddah Central's smart city framework to its unique needs, resources, and challenges to ensure sustainable and effective implementation.



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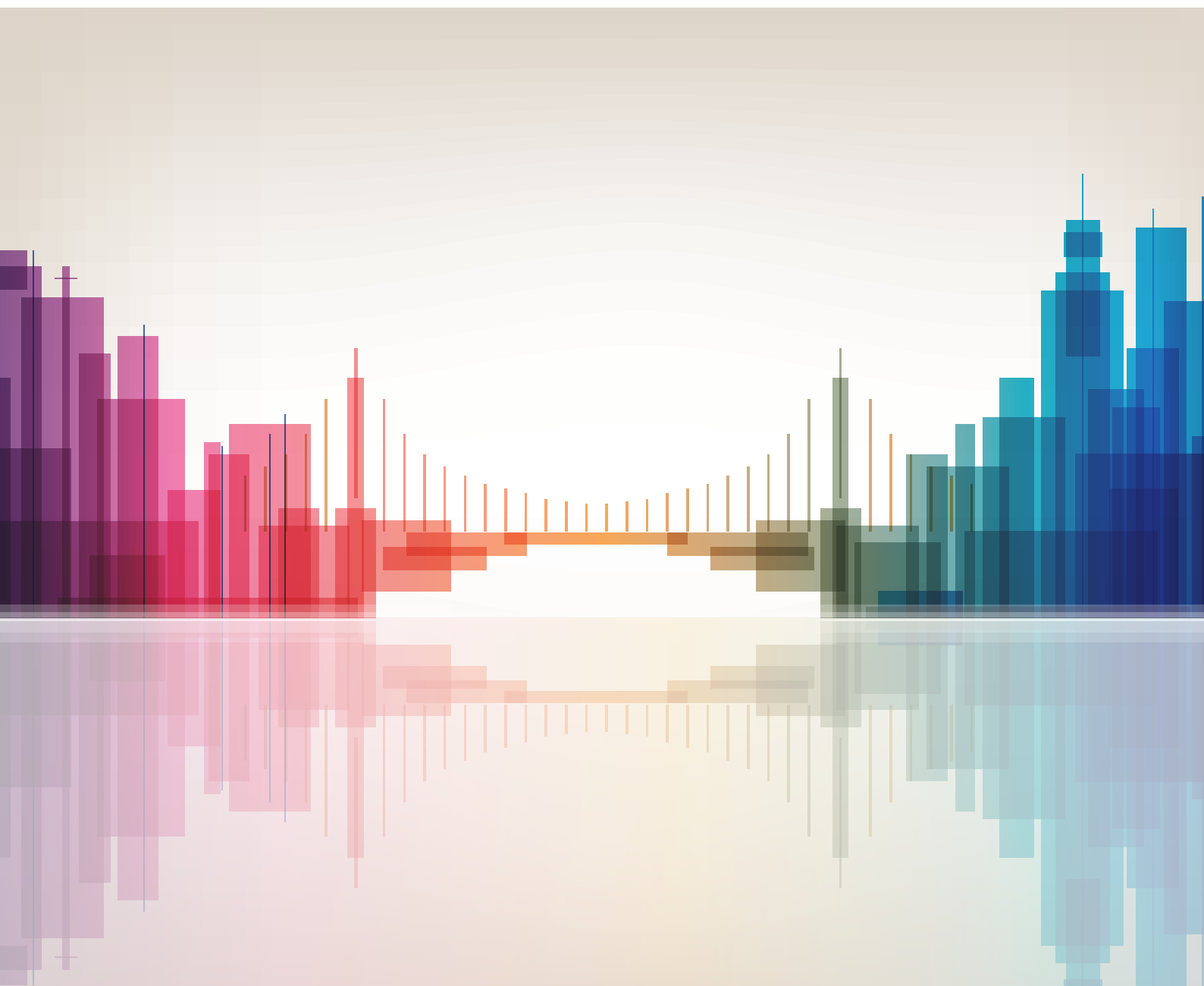
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