Benchmark NSW

Final Report

November, 2024

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Massachusetts Institute of Technology

LCAU

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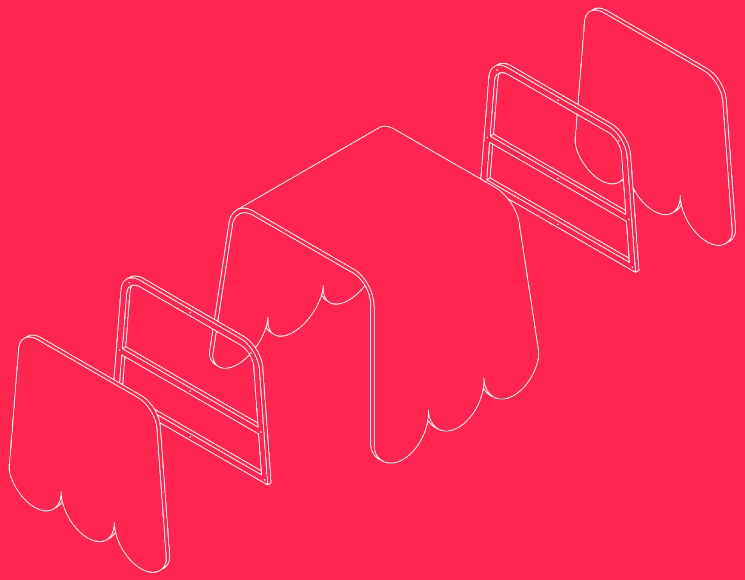


I. Executive Summary

Benchmark New South Wales (NSW) is an experimental, temporary outdoor seating initiative designed to understand how women, girls, and gender diverse people use public spaces. Conducted as a collaboration between the University of New South Wales (UNSW), Massachusetts Institute of Technology (MIT), and Transport for NSW (TfNSW), the project introduced modular, movable seating with integrated motion-activated LED lighting. The seating was monitored using AI-driven computer vision recognition software developed by MIT team to collect data on how people interact with their urban environment.

This project was funded by Transport for NSW's Safer Cities program, a $30 million initiative aimed at enhancing perceptions of safety in public spaces, particularly for women, girls and gender diverse people.

Inspired by MIT's original Benchmark initiative in 2017, Benchmark NSW adapted this model to local cultural and environmental contexts, reflecting Sydney's values and leveraging the latest advancements in AI technology. The seating units, fabricated from post-consumer recycled high-density polyethylene (HDPE), were co-designed by women Industrial Design students at UNSW, emphasising social interaction, safety, and sustainability.

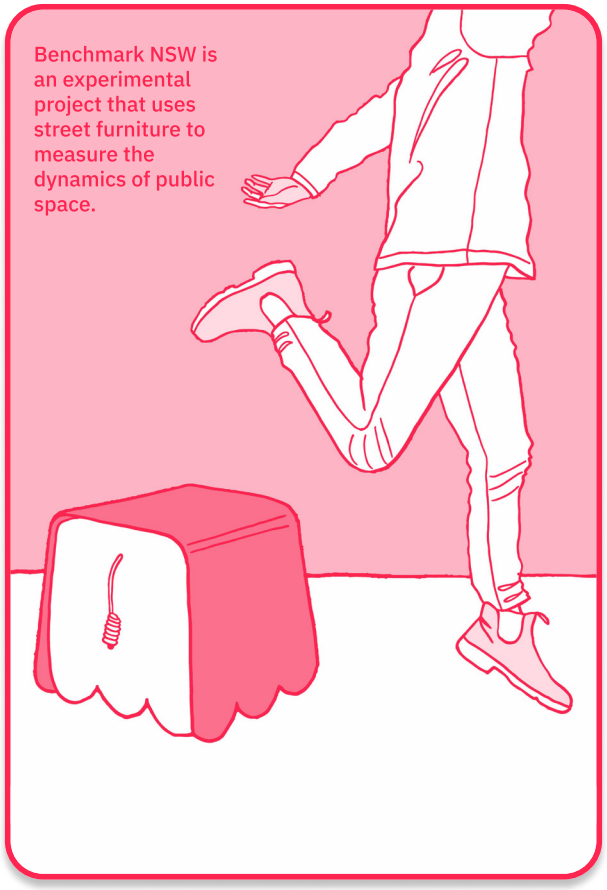
Installed near the UNSW Village Green, the project utilised computer vision sensors to monitor how users interacted with the seating and the surrounding environment. These sensors anonymised data at the source to ensure privacy, allowing for the collection of valuable insights about usage patterns, pedestrian traffic, and social interaction. The data collected provides critical future public space planning insights, particularly focused on enhancing inclusivity and perceptions of safety.

The technology in the sensor kit is documented in a comprehensive Do-It-Yourself Benchmark NSW Guidebook, enabling place managers, researchers and other interested parties to conduct their own public space research. This open-source guidebook will be available for urban planners, community organisations, and researchers, offering refined methodologies that empower others to start similar projects and contribute to data-driven urban planning initiatives.

Key outcomes of the project include:

- The number of people staying grew five times after benches were set up, based on the data collected through computer vision AI sensor.
- The number of women and girls staying on site increased eight times after benches were deployed, based on human observation.
- The number of people staying at night grew six times after benches were installed, based on the data collected through the AI camera vision sensor.
- The benches facilitated social life. Community feedback highlighted the seating's approachability and flexibility, with 85% of respondents of the survey conducted noting that the seating made social interaction easier.
- The benches increased comfort. The modular design allowed users to personalise the space, fostering a greater sense of ownership and comfort. In fact, 73% of women survey respondents said the seating made them more comfortable.

Completed over a five-month period, Benchmark NSW demonstrated the potential of smart technology and design to better understand how people use urban areas and provide insights into perceptions of safety and inclusivity in public spaces. The success of the project underscores the importance of interdisciplinary collaboration and sets a strong foundation for future applications in urban planning, particularly those that prioritise women, girls, and gender diverse people.


Benchmark NSW is an experimental project that uses street furniture to measure the dynamics of public space.


The project seeks to understand how UNSW students, particularly women, girls and gender diverse people interact with and move seating in public space.
It combined co-design, sensor kit development, and data analysis to assess the impact of a temporary activation on open space at UNSW.

II. Benchmark NSW

BACKGROUND

One of the most challenging problems facing urban designers and planners today is the difficulty of developing robust and effective methods of studying public spaces to help inform design. At its core, this problem revolves around measuring "Public Life," a term often referenced in Jan Gehl's work that refers to citizens' daily interactions with others within the built environment. In How to Study Public Life (2013), Jan Gehl and Birgitte Svarre propose a systematic methodology to study the interaction between public life and public space, drawing from 50 years of research and urban design work. This methodology gives particular attention to the human scale of people's activities and interactions.

In general, urban designers measure human interactions within space via in-person observations and manual data collection. Gehl writes that relying on the human eye for data collection has both benefits and drawbacks. Compared to GPS and surveillance cameras, human researchers observing public spaces lose positional and temporal accuracy. However, in-person observations provide rich contextual information that informs us about why observed interactions occur in specific ways. The original Benchmark project set out to bridge the gap between automated data collection and in-person observations. The goal of the project was to develop data collection methods that match the effectiveness of a human collecting positional and temporal data so the human observer can be relieved of that duty, thus resulting in better qualitative urban descriptions and research.

Benchmark NSW was informed by co-design and deployed with a specific focus on how women, girls and gender diverse people use public space. This project sought to understand and contribute to the growing body of knowledge of how to improve the perception of safety for women, girls and gender diverse people in public space and create more welcoming and equitable places for everyone. Benchmark NSW is part of the Transport for NSW's Safer Cities program which aligns with the United Nations Safer Cities for Girls and has three core aims:

- Enhancing safety and improving access to public spaces for women, girls and gender diverse people.
- Enabling women, girls and gender diverse people. to move freely and independently within their communities.
- Increasing engagement with women, girls and gender diverse people in the design and management of public spaces.

Benchmark NSW sought to create a temporary seating activation that not only serves its basic function but also contributes to an improved feeling of safety and a more inclusive public environment. The project also focused on understanding how the physical and social design of public spaces can influence perceptions of safety and improve the experiences of women, girls, and gender diverse people. Benchmark NSW explored how gender can impact the way public spaces are used and enjoyed and aimed to create an environment that embraced diversity and fostered a more inclusive, welcoming, and equitable public realm.

Despite the assumption that the built environment is gender neutral, public spaces have historically not been designed with the needs of women, girls, and gender diverse people in mind. These groups have been underrepresented in the planning, design, and management of public spaces and infrastructure. While urban design is often seen as objective and unbiased, this view overlooks how different identities and intersecting characteristics shape people's experiences of these spaces.

By centring diverse voices in the planning, design, and management of urban spaces, Benchmark NSW sought to address these biases and promote more inclusive design practices. The goal was to create public spaces where all users, regardless of gender identity, feel safe and welcome to move through, stay and/or socialise.

The project leveraged previous co-design and engagement with women, girls, and gender diverse people as part of the Safer Cities program. This feedback emphasised the need for places that are inclusive, welcoming, and easy to navigate, while also acknowledging that different users may experience public spaces differently based on their gender identity and other intersecting factors. These insights were critical in shaping the project approach to creating smart seating solutions that directly address the needs of women, girls, and gender diverse people.

GOALS AND OBJECTIVES

The overarching goal of Benchmark NSW was to leverage the original Benchmark project methodology and design, manufacture and test temporary smart seating solutions on the UNSW Campus to better understand how women, girls and gender diverse people use public space. Through collaboration and co-design, the project aimed to promote inclusivity, foster a welcoming environment, and enhance perceptions of safety in public spaces as well as embody the local character and aesthetic values. Additionally, it sought to incorporate advanced technology to collect spatiotemporal data, enabling the evaluation of the temporary seating activation.

Benchmark NSW aimed to:

- Engage women in the co-design process, allowing them to participate in both the design and production of the seating solutions.
- Design seating that responds to the needs and behaviours of local women, girls, and gender diverse people, creating a more inclusive and welcoming public environment.
- Incorporate smart technology into the seating design to enhance comfort, safety, and functionality while also reflecting Sydney's unique cultural and aesthetic values.
- Develop a sensor kit to collect spatiotemporal data on bench usage patterns and pedestrian traffic to evaluate the success of the benches in activating public space.
- Trial the co-designed benches on the UNSW campus by collecting data on how women, girls, and gender diverse people move through and interact with public spaces.
- Share the results with the public through an interactive web application, showcasing how co-designed benches activate public spaces and facilitate social interactions.
- Provide a Do-It-Yourself Guidebook for the sensor kit, empowering place managers, researchers, urban planners and other interested parties to build their own projects and undertake data-driven projects.

PROJECT METHODOLOGY

Benchmark NSW was structured around a methodology designed to engage stakeholders, gather meaningful data, and assess the effectiveness of the interventions on public space activation and inclusivity. This section outlines the key phases of the project, from initiation to deployment and documentation, as well as the methods employed to ensure robust data collection and community engagement.

Project initiation, planning, and research design

The project began in April 2024 with an initiation workshop, which served to confirm the project scope and establish the key planning, development, and engagement activities. The primary objective during this phase was to set a strong foundation for the research, including the following activities:

- **Scope Definition.**
  The team clarified the scope of the project, detailing the interventions to be developed and outlining their objectives, such as enhancing inclusivity and perceptions of safety in public spaces for women, girls, and gender diverse people.
- **Research Design.**
  A research framework was developed, incorporating key research questions, data collection methods, and ethical considerations. The team also established the methodology for analysing the data, ensuring the approach was both systematic and aligned with ethical standards.
- **Ethics Approval.**
  Given the involvement of human participants and public space observation, ethics approval was obtained in line with standard university protocols. This ensured that all data collection was conducted with transparency, consent, and respect for privacy.

The project initiation, planning, and research design stage established a structured and ethically sound foundation for the research project, clarifying the data collection tools and analysis methods to be used.

PROJECT METHODOLOGY (continued)

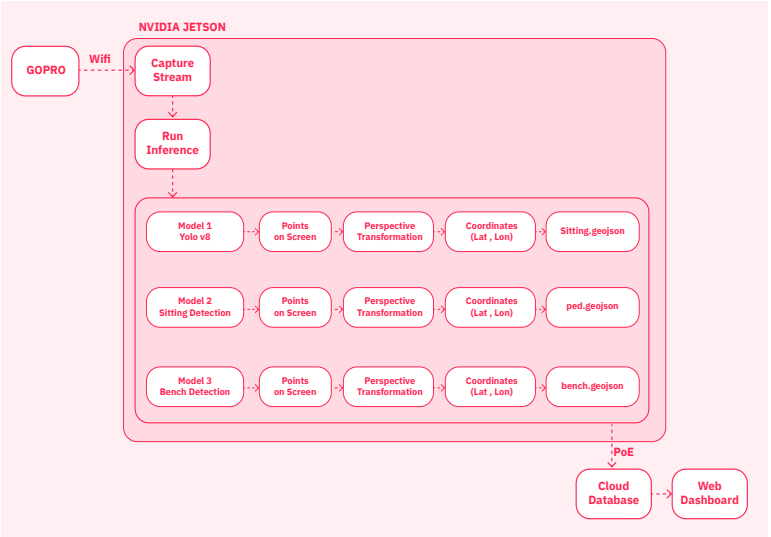
Co-design and technology development

During May and June 2024, the project shifted to focus on the co-design of the seating and the development of the accompanying technology. This phase involved close collaboration with stakeholders, including women UNSW Industrial Design students and staff, to ensure the solutions were both inclusive and user-centred.

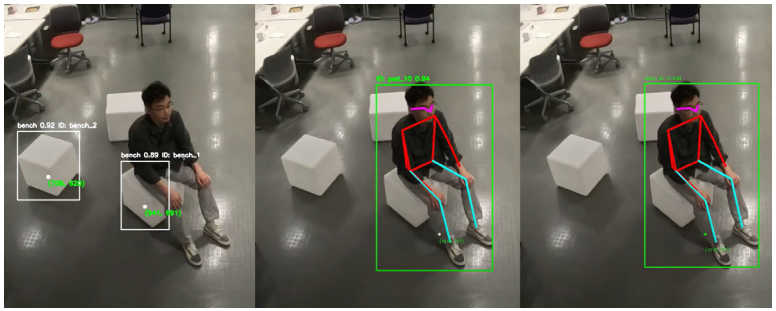
- **Co-design process.**
  A co-design workshop was held with a group of women UNSW Industrial Design students. Their participation provided invaluable women-led expertise and first-hand insights into the specific needs of women in public spaces. This process ensured that the design of the benches, sensors, and overall interventions was both user-friendly and reflective of real-world experiences.

- **Technology development.**
  MIT team developed the necessary technology to support data collection, specifically the AI-driven computer vision sensors that would track bench location, pedestrian movement, sitting behaviour, and social interactions within the space. The integration of this technology was a critical aspect of the project, enabling real-time data capture without the need for intrusive or obtrusive devices.

- **Prototype testing.**
  Once initial designs were finalised, a round of prototype testing was conducted to ensure the physical seating units and sensor systems functioned as intended. Feedback from this testing phase allowed for iterative improvements to be made before the final deployment.



Technology development. Sensor kit data process diagram



Prototype testing: multiple model real-time async inference test

PROJECT METHODOLOGY (continued)

- **Development of the Benchmark NSW DTPR.**

  The Benchmark NSW project adopted the Digital Trust for Places & Routines (DTPR) framework, an open-source communication standard designed to enhance transparency and accountability in the use of digital technology in public spaces. The Benchmark NSW implementation follows the DTPR design guidelines, focusing on providing clear, accessible information across five key aspects:

  - Type of Technology: What technology is being used?
  - Purpose: What is the purpose of this technology?
  - Data Processing: How will the collected data be processed?
  - Data Storage: How is the data stored?
  - Data Access: Who can access this data?

Each of these areas were addressed to ensure the public were aware of the types of technology were being use, the data used and reasons for doing so. To make this information accessible, a dedicated website was created with comprehensive DTPR descriptions, bringing transparency to this project.

Visitors can easily reach the DTPR page by scanning QR codes on signs located throughout the research area. This setup allowed the publicto stay informed about the project, fostering a transparent and responsible approach to digital sensing in public spaces.

DPTR signage used in Benchmark NSW project

Deployment and data collection

In July 2024, the co-designed temporary benches and technology were installed in the selected location, marking the beginning of the data collection phase. This phase lasted until August 2024 and involved several key steps:

- **Baseline data collection.**

  A one-week baseline data collection period was conducted without the benches in place, allowing the team to capture standard patterns of pedestrian flow and public space use without the installed interventions.

- **Intervention installation.**

  The finalised temporary benches and computer vision sensors were installed in the selected public space. The sensors were positioned strategically to monitor not only the seating but the surrounding environment, ensuring comprehensive data collection on pedestrian movements, social interactions, and public behaviour.

- **Data collection with interventions**.

  For two weeks following the installation, the AI-driven sensors collected data in real time, capturing changes in how people used the space with the seating in place. The sensors tracked patterns such as: how the benches were moved around and used; how long people stayed in the area; whether the seating encouraged social interaction; and general pedestrian traffic patterns in the vicinity of the seating.

- **Observations and surveys.**

  In addition to the sensor data, on-site observations were conducted by the research team to further understand public interactions with the seating, including gender segregated data capture. Survey tools were also used to gather qualitative insights from people in the area and/or interacting with the benches, ensuring that the data captured both quantitative and qualitative perspectives on the impact of the intervention.

The deployment and data collection stage was critical for assessing the effectiveness of the interventions. The project included a baseline for comparison and real-time data that measured the impact of the role of the temporary seating activation.

Gopro device installed

Data sample colleted from MIT computer vision sensor

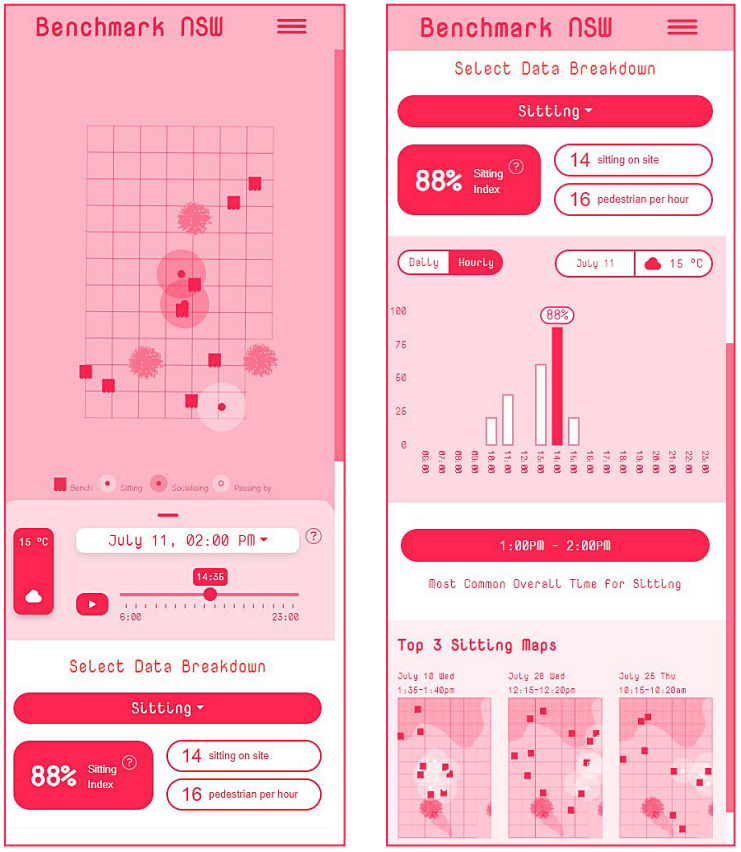
PROJECT METHODOLOGY (continued)

Documentation and dissemination

The final phase of the project, running from August to November 2024, focused on documenting the research findings and ensuring that the data and insights were shared with the broader community:

- **Data analysis.**
  The data collected from the sensors, surveys, and observations were analysed to identify patterns and assess the impact of the interventions. The analysis revealed key areas for improvement and confirmed the effectiveness of the benches in enhancing social interaction and creating a more active and welcoming environment.
- **Interactive dashboard.**
  An interactive dashboard was developed to visualise the data, making it accessible to both the project team and the public. This dashboard displayed key insights such as staying, seating usage statistics, and social activity changes. The dashboard was designed to be intuitive, enabling community members to explore the data and understand the project's impact.
- **Guidebook and report.**
  A user-friendly guidebook was created to document the sensor technology enabling users to develop their own sensor kit to study public spaces. This guidebook was made available via the dedicated project website, which served as a hub for all project-related resources, including the dashboard and data visualisations.

The documentation and dissemination stage ensured that the project's outcomes were transparent and accessible, fostering ongoing engagement with the findings and encouraging the application of the insights in future public space projects.



Snapshots of the interactive dashboard in which a user can view bench locations, weather, graphs and movement data at any point during the project, available on Benchmark NSW website

LESSONS LEARNT

- **Human research ethics compliance.**

  The complexity of obtaining Human Research Ethics Compliance (HREC) approvals impacted the project timeline. The ethics approval process, initiated in August 2023, was prolonged due to the evolving nature of the research activities and the need for multiple applications. The final approval for the second ethics application was only received in May 2024, just a week before the co-design and fabrication process began. More time in the planning stage should be added to allow for approval timeframes.

- **Privacy with computer vision sensors.**

  Implementing computer vision sensors can pose a challenge in addressing privacy concerns and ensuring ethical compliance. Therefore, the project team had to carefully explain the sensor's functionality to the ethics committee, emphasising that no photographic or video data would be stored. Allowing for the appropriate privacy assessments and protocols such as deploying Digital Trust for Places and Routines (DTPR) is important to plan for at the beginning of the project.

- **Modifications to research activities.**

  The project relied upon insights gained from the other projects and research undertaken in the Safer Cities program rather than undertaking another co-design process with the community. The co-design workshops were limited to UNSW women Industrial Design students who had the design skills to translate research findings into product designs. If a full co-design process involving the wider community and/or a diverse group of girls, women and gender diverse people is desired in future, sufficient time should be planned for the process at the beginning of the project.

- **Recruitment and onboarding delays.**

  Recruiting and onboarding the women co-designers from the UNSW Industrial Design program faced delays, with the first official meeting only occurring at the end of May 2024. This delay compressed the time available for the co-design phase, which had to be compressed to consider the start of the UNSW Academic Term 2 calendar. In future projects, ensure that recruitment is done as early as possible to avoid any delays, whether it's for students or a cohort of participants for co-design.

- **Technical and logistical challenges.**

  The fabrication of the seating was dependent on the timely supply of 100% recycled HDPE boards, which were made-to-order by the supplier. Any delays in material supply directly impacted the fabrication schedule, which took place at the UNSW Design Futures Lab between 4 June and 2 July 2024. This should be noted as a risk and additional lead time to be added in the project timeline to account for any delays in fabrication.

III. Bench Design

The Benchmark NSW design process centred around the creation of public outdoor seating that is both functional and aesthetically engaging, while also integrating smart technology, safety, and sustainability. The process unfolded in several stages, each involving collaboration between UNSW Industrial Design students and staff and advanced urbanism experts from MIT. From concept development to final fabrication, the design process emphasised inclusivity, flexibility, and technological innovation.

Co-design Process

Phase 1: Project Briefing & Scope Definition (Day 1)

This phase focused on introducing the project objectives, scope, and constraints. The co-designers were briefed on the challenge: designing smart seating to improve safety for women and girls in public spaces. Key considerations such as user experience, material choices, and environmental sustainability were highlighted, setting the foundation for their independent research and ideation.

The 1-hour project briefing was held with the project team and the co-designers.

To meet the objectives of the project, the following design criteria were established for the seating solutions:

- **Mobility and flexibility.**
  The seating must be lightweight and easily movable so that users can reposition the units as needed. This flexibility will foster social interactions and enable users to arrange the seating in ways that suit their preferences, enhancing the usability and social dynamics of the space.
- **Modularity.**
  The seating must be modular, allowing for easy reconfiguration into various forms such as long benches or circular setups for groups. This adaptability encourages playfulness and accommodates the diverse ways that people use public spaces.
- **Visibility and material use.**
  The seating must be highly visible, especially at night, to enhance safety. Materials should be chosen for their ability to stand out in different lighting conditions. Additionally, the seating must include a distinctive light that activates when the seating is in use, improving detectability.
- **Shape, size, and proportion.**
  The seating must have unique, recognisable shapes that are easy to identify from various angles, aiding surveillance and safety monitoring. The design should balance engaging aesthetics with durability, ensuring that the seating is robust yet inviting.
- **Technology integration.**
  The seating should include Ultra-Wideband (UWB) sensors to detect accurate bench locations in real-time, contributing to management and user safety (note: the final sensor kit ended up not needing this technology). Other technologies could also be integrated to enhance interactivity and functionality, such as motion-activated lighting.
- **Ecological impact.**
  The seating must be designed with sustainability in mind, using materials with minimal environmental impact. Post-consumer recycled plastics preferred to ensure durability, weather resistance, and alignment with circular economy principles.
- **Passive surveillance.**
  The seating design must not obstruct sightlines, promoting visibility and natural monitoring of the environment by users and passersby, contributing to a sense of safety in the public space.
- **Inclusive and accessible.**
  The seating must include ergonomic features that ensure comfort and prolonged use. It must cater to a diverse range of users, with designs that prevent falls and ensure accessibility for people of different physical abilities.

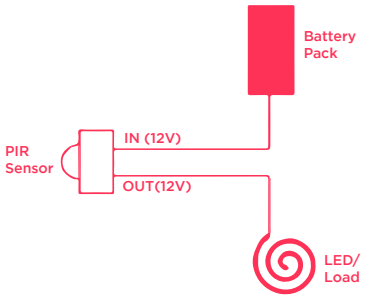
Co-design Process (continued)

- **Aesthetic and cultural integration.**
  The design must reflect Sydney's urban character and cultural values. It should blend into public spaces while providing a fun and engaging addition to the urban landscape.

The success of the project was evaluated based on the following criteria:

- **Innovation and originality in design.**
  The extent to which the design introduces new ideas or innovative approaches to public seating.
- **Effectiveness in responding to the needs of target groups.**
  The degree to which the design addresses the specific behaviours and requirements of local women, girls, and gender diverse people.
- **Aesthetic and functional integration into public spaces.**
  How well the seating complements the surrounding environment, both visually and functionally.
- **Practicality of the design.**
  The ease with which the seating can be manufactured, installed, and maintained.
- **Ease of fabrication using local facilities.**
  The feasibility of producing the seating using local resources and available manufacturing technologies.

Circuit Diagram



Circuit diagram for motion activated LED sensor

Image Credit: Robert Walsh

Co-design Process (continued)

Phase 2: Contextual Research & Initial Concept Presentation (Day 4)

Following the establishment of the design criteria, this phase saw the development of a variety of seating solutions that aimed to meet the project's goals of inclusivity, perceptions of safety, and interaction. Each concept was driven by the need to create flexible, engaging public seating that reflects the values of the Safer Cities program while also integrating smart technology and sustainable practices.

After conducting individual research—including site visits and distilling inspirations into mood boards—the co-designers presented their insights alongside their initial concepts at the end of May 2024.

Phase 3: Concept Development & Feedback Iteration (Day 8)

The co-designers advanced their initial concepts by incorporating feedback and iterating on the original designs. Each co-designer refined their ideas, addressing issues of modularity, safety, comfort, and interaction while integrating further insights from feedback. The presentations demonstrated adjustments based on feasibility, material choices, and technology integration. Overall, there were notable evolutions and adjustments in design direction, but many core principles from Phase 2 remained.

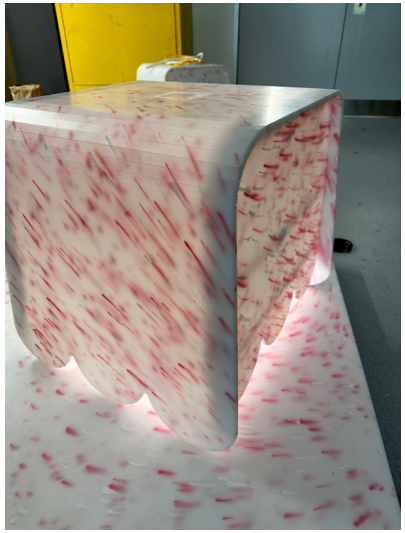
Phase 4: Final Presentation & Prototype Testing (Day 14)

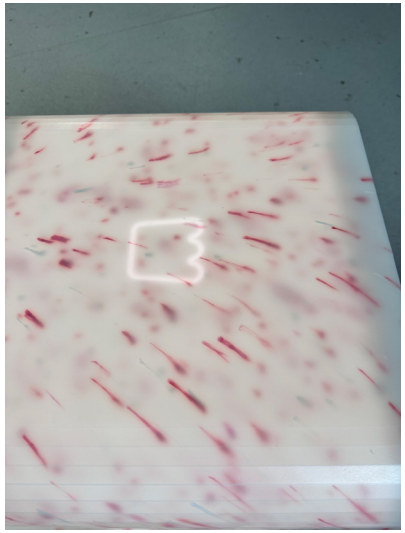
The co-designers presented their final seating designs, incorporating the feedback and refinements from the previous phases while showcasing their fully developed concepts. These final presentations demonstrated significant progress, with an emphasis on ergonomics, safety, sustainability, and smart technology integration. The designs were geared toward real-world implementation, with considerations for material choices, manufacturing processes, and user interaction. While certain elements from Phases 2 and 3 were retained, this phase focused on refining the solutions into fully functioning prototypes.

Meterial Color Detection Test on Grass : Blue, Red, and White

Phase 5: Design Synthesis & Full-Scale Fabrication (Post-Day 14)

Phase 5 marked a pivotal shift towards the synthesis of the co-designed ideas and the development of the full-scale prototype. This phase involved the UNSW Project Lead synthesising the insights gathered throughout the co-design process and making critical design decisions to finalise the seating solutions. The result was a full-scale, fabricated installation that differed in some key aspects from the original proposals while still reflecting the overarching goals of the project. The final design emphasised playfulness, flexibility and visibility, and compatibility with the advanced AI sensor technology, tailored to enhance the public space experience for women, girls, and gender diverse people.





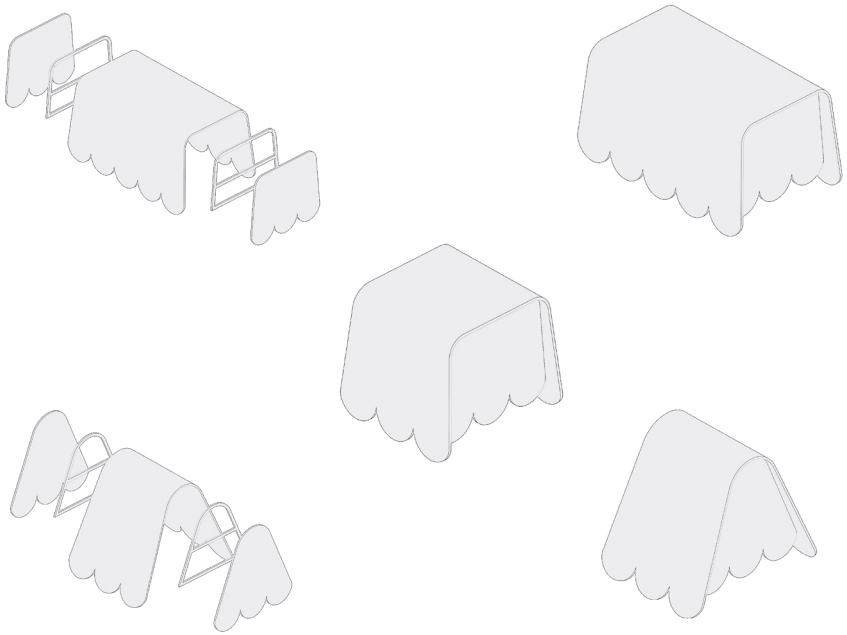
Fabrication of Full-scale Functional Prototypes at UNSW Design Futures Lab

Image Credit: Robert Walsh

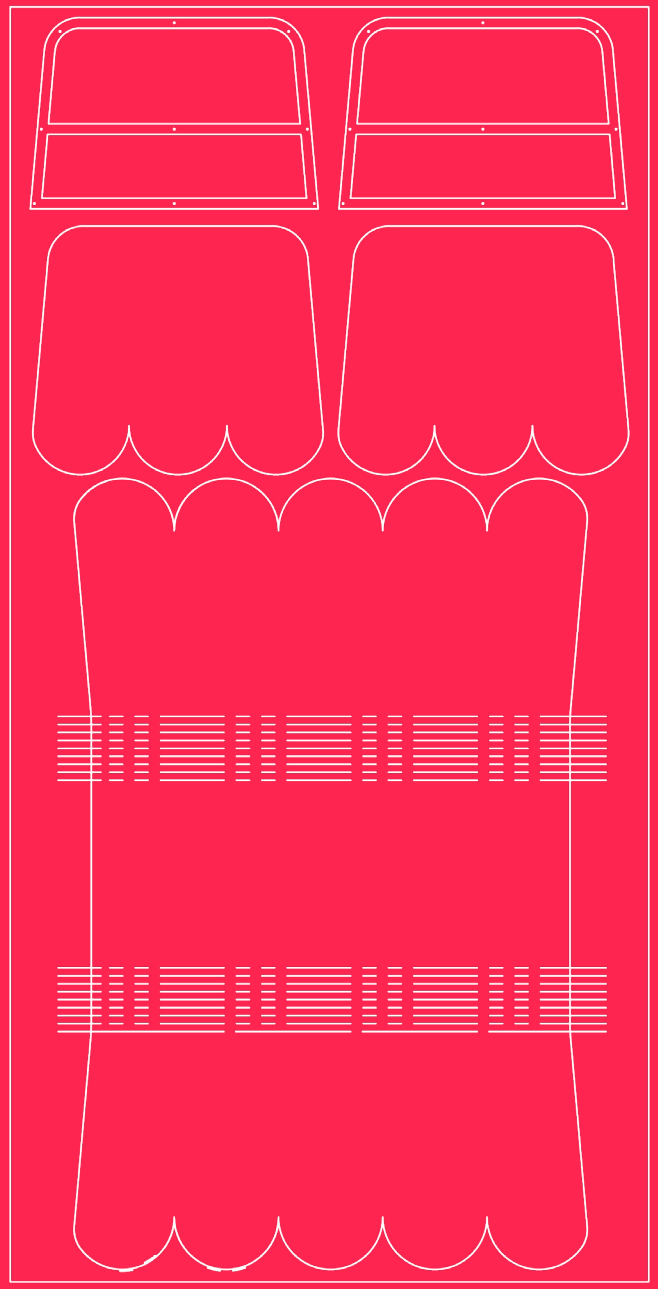
Image Credit: Robert Walsh

Final Product Design

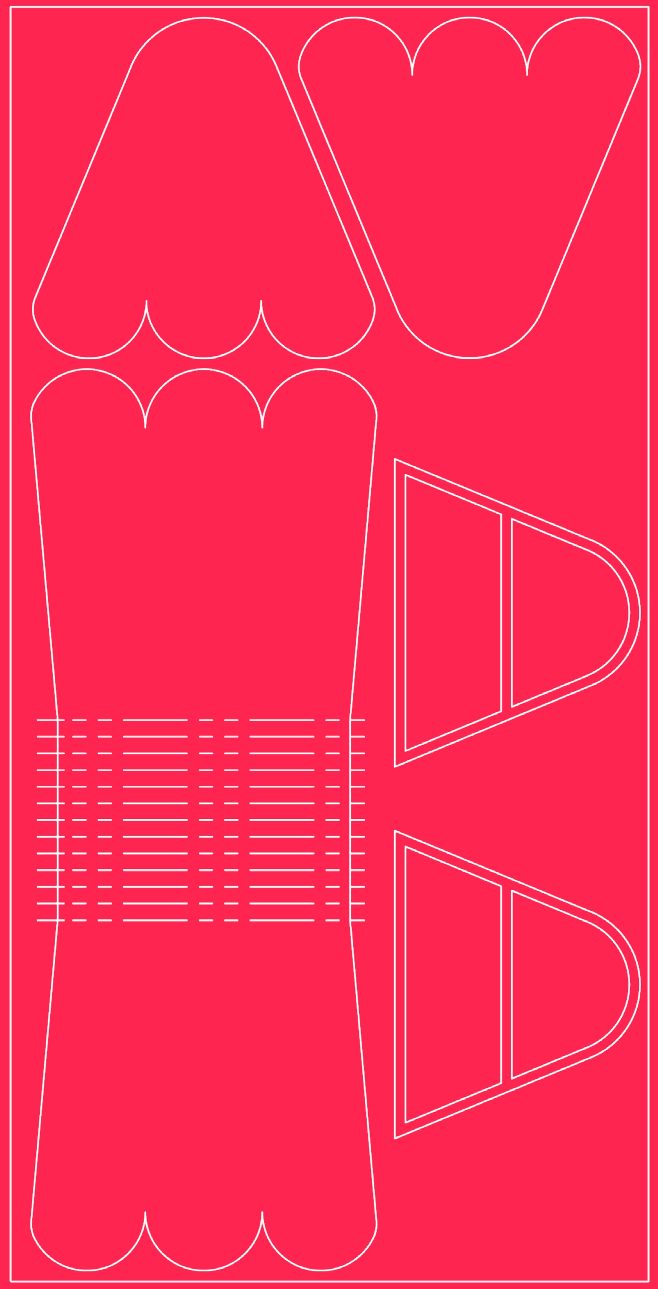
The final product design for Benchmark NSW brought together aesthetic appeal, functionality, technological innovation, sustainability, and a carefully considered fabrication process. The seating was designed to create an inviting public space while meeting the objectives of improving feelings of safety, engagement, and inclusivity for women, girls, and gender diverse people.



Isometric Drawings and Exploded Views of Final Design for fabrication



CNC Cutting Diagrams of Full-size Prototypes



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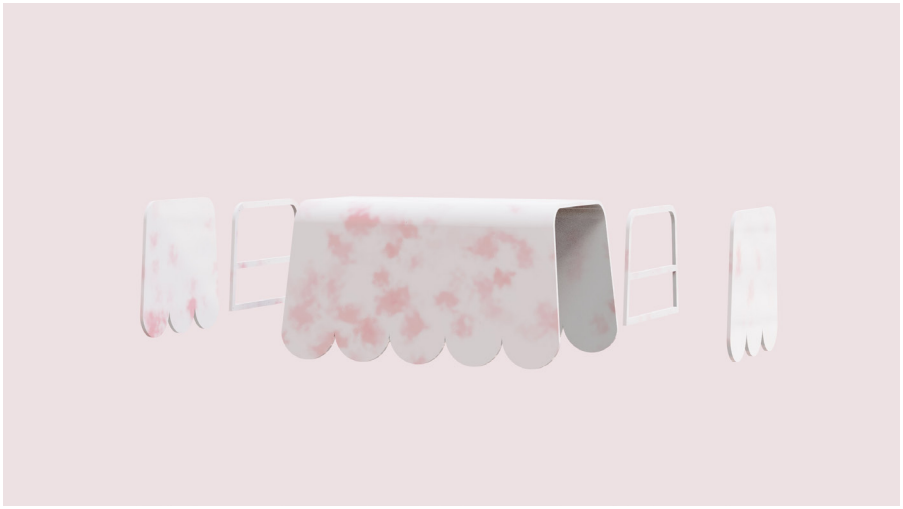


3D Digital Visualisations of Final Design for Fabrication

3D Digital Visualisations of Final Design for Fabrication

Image Credit: Robert Walsh

Fully-finished Full-size Prototypes. Image Credit: Robert Walsh

Fully-finished Full-size Prototypes. Image Credit: Robert Walsh

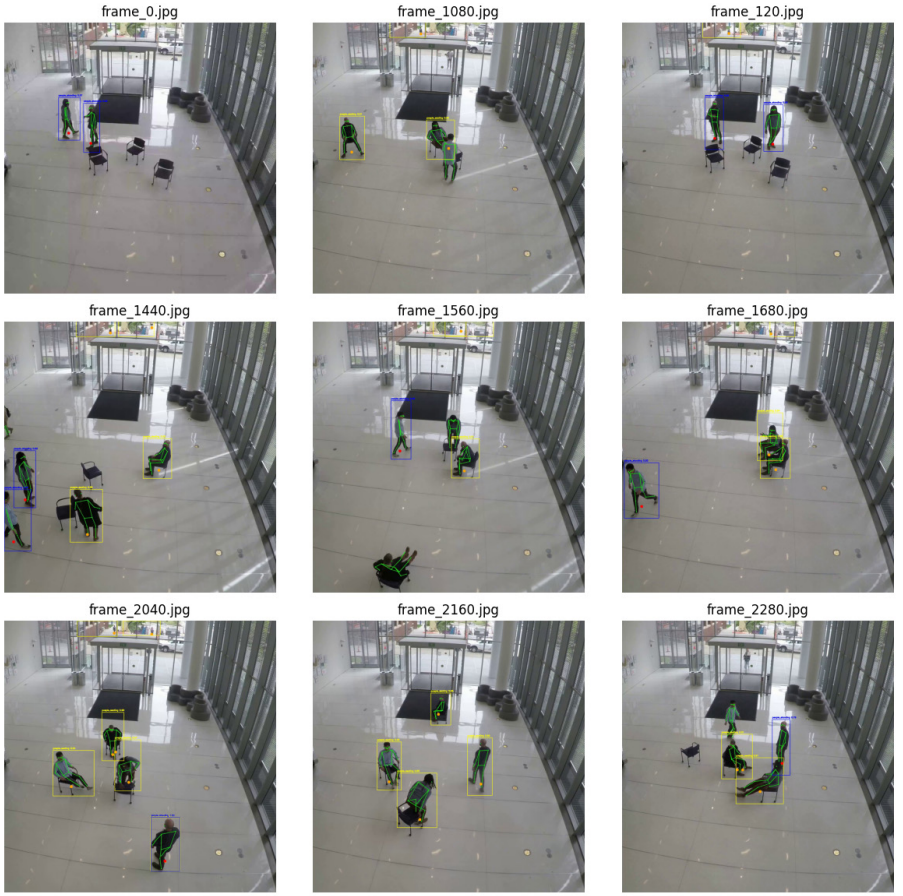
IV. Sensor Technology

Why Computer Vision?
Key Principles for Sensor Design

Benchmark NSW builds on the original Benchmark initiative, conducted at the Massachusetts Institute of Technology (MIT) in 2017 and 2019. The earlier project experimented with various sensor combinations to study public spaces, including an early-stage YOLO v3 vision recognition model. The model proved far more accurate than other technologies, such as pressure sensors that struggled to differentiate between objects and people, or GPS and WiFi, which lacked the precision necessary for analysing social interactions happening within a 1-meter scale. Benchmark NSW advances this work by integrating more advanced technologies, aiming to create a scalable and customisable framework for public space analysis and public life study while ensuring privacy and transparency.

Since the original Benchmark initiative, computer vision has evolved significantly over the past seven years. Initially, it was expected that off-the-shelf sensor solutions for public space analysis to be readily available. However, after launching our project in April 2024 and consulting with multiple company specialists, several challenges were encountered. The most significant was the lack of support for custom model integration, as many companies focused on transportation analytics or smart surveillance systems. While some offered custom development services, the tight deployment deadline limited the ability to pursue these options.

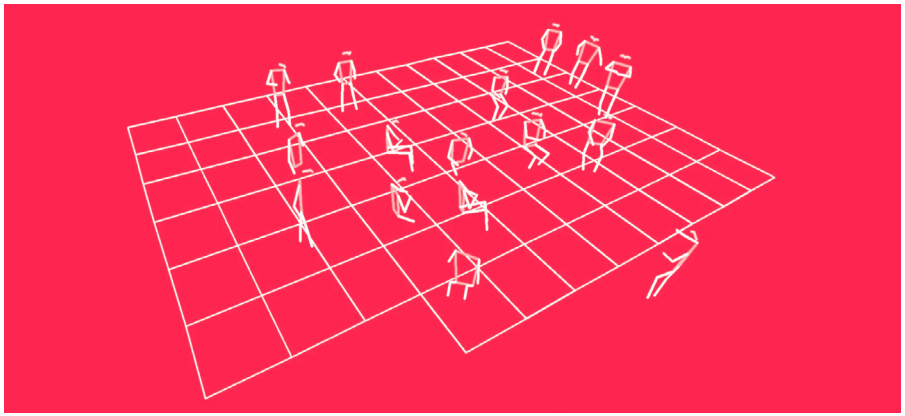
Customisability became a central focus of the sensor technology design, allowing for the adaption to the unique characteristics of public spaces in different countries, cultures, and cities. Ultimately, it was decided that MIT would develop their own solution for Benchmark NSW, requiring a custom model capable of detecting whether people were sitting or standing, and analysing co-designed bench prototypes that didn't yet exist in real-world environments.



Sitting Detection Computer Vision Model Test @ MIT Media Lab

Sensor kit package

Sensor installing on site



Visualisation of bench users as stick figures

Scalability was another priority. When determining how to track the location and time data of benches, two options were considered: Ultra-Wideband (UWB) technology and vision recognition. Vision-based recognition was chosen for its reliability and simplicity, which also avoided the high costs and complex wiring that would have been required by UWB technology. Although UWB could provide 0.1-meter precision, it required PoE Ethernet connections, making it impractical for most urban environments.

By leveraging open-source vision platforms and cost-effective hardware, cost of each sensor kit was reduced to under $1,000, enabling real-time inferences and video capture. To ensure the scalability of the project, the entire process is documented in a Do-it-Yourself Benchmark NSW Guidebook. This open-source resource will empower urban planners, community organisations, and researchers to replicate similar public space studies, fostering data-driven urban planning initiatives by offering practical, adaptable methodologies.

Privacy and transparency are central to the project, given that it operates in real-world public spaces. A key feature of the software is that no video or images are stored, ensuring the protection of privacy. Additionally, the project incorporates the Digital Trust for Places & Routines (DTPR) framework, an open-source standard that enhances transparency and accountability in the use of digital technologies in public spaces. This commitment to privacy and transparency ensures that the project adheres to ethical standards while providing valuable urban insights.

How Does Vision AI Work? The Data It Collects

The sensor system comprises both hardware and software components. On the hardware side, a GoPro camera streams video footage and a Nvidia Jetson Orin Nano is used to run three object detection models simultaneously: pedestrian detection, sitting detection, and bench detection. These models process video frames approximately every five seconds. With advancements in on-device machine learning, all video footage was able to be deleted in real-time, eliminating the need to transmit raw video to external platforms.

Once the camera captures images, the detection models immediately process them, recording data such as coordinates within the video frame and stick figures for behavioural analysis. This data is then transformed into usable geographic coordinates by applying a homographic transformation matrix, converting image-based coordinates into actual latitude and longitude using a predefined grid setup. After processing, the detection data is uploaded to the cloud, and the image cache is promptly deleted. Each cycle takes approximately 3 to 5 seconds. Over a three-week period, around 500 MB of data was collected in GeoJSON format—two weeks with benches installed and one baseline week without them.

These algorithms interpret visual inputs and convert them into actionable insights, such as the number of people using the space and how long they stay. By processing thousands of data points, the AI generates reliable, scalable metrics on human interaction with public spaces, which can then inform urban design improvements. For example, data on social interactions near seating areas can help assess the success of interventions in fostering a sense of community.

How Does the Technology Work? Explaining It with DTPR Taxonomy

A core aspect of the sensor technology design is its accessibility for a non-technical audience. The aim is to clearly communicate essential information across five key categories, ensuring transparency in how data is collected and processed while upholding strict privacy protections. Outlined below are the types of technology in use, the data collected, and the purpose behind using DTPR

What type of technology is this?

De-identified video
collects video footage of a sufficient resolution where people can be identified, for example by capturing images of faces or unique numbers such as vehicle license plates. However, the video is processed in a way that removes identifying characteristics before it is used or stored (known as de-identified before first use or de-identified on device), for example by blurring faces using computer vision.

Person detection
refers to when a system can detect the presence of humans in images or videos, and identify where they are located or how many there are in an image, but does not identify people. The technology does not retain or use any personally identifiable information.

A motion detector
is a sensor that detects the movement of nearby objects. This project uses motion detection only for lighting and does not capture data.

What is the purpose of this technology?

Planning & Decision-making
supports the development of future plans; or to enable or measure the impact of a decision. Examples include urban planning.

Research & Development
supports exploratory research and testing.

How will this data be processed?

Artificial intelligence
data that is processed by automated, algorithmic or artificial intelligence systems to derive a new result or data point. Specifically, the project uses computer vision, which refers to computer science methodologies that enable computers to derive data from digital images or video. The project processes de-identified video with an algorithm called YOLOv8.

Reviewed internally
the NSW Government has review processes that consider the potential benefits, risks and implications for privacy and harm for new technologies or data collection activities. The NSW Government Artificial Intelligence Assurance Framework was completed, and the team constantly assesses the data for accuracy and inconsistencies.

How is the data stored?

Cloud storage
Anonymised data is stored on behalf of the organization or the data collector in an off-site data centre.

Encrypted
Data has been encoded so that only authorised parties can access it, which can reduce risk related to handling private or sensitive information.

Who can access this data?

Data is available to the accountable organisation - University of NSW. It is also available to Transport for NSW as well as MIT Leventhal Center for Advanced Urbanism.

What Are the Pros and Cons of the Sensor Kit? Impact and Future Opportunities

The sensor kit offers several key advantages, notably scalability and customisability, made possible by its use of open-source software that is freely accessible to anyone. It provides actionable insights, such as the number of people using the space and their dwell time, while processing thousands of data points to generate reliable metrics on public space interactions. These insights can inform urban design improvements, such as evaluating the success of seating interventions in fostering social interactions.

However, there are limitations. Computer vision cannot directly collect gender related data, which presents a recurring challenge for projects that require information beyond what can be captured visually. This type of data often necessitates qualitative surveys or other participatory approaches. Future versions of the system could integrate these methods with the Vision AI framework to bridge this gap, however this comes with misrepresentation risk.

The GoPro was chosen for its outdoor durability and its software development kit (SDK), which allows remote control over a wireless connection. However, it was found that the GoPro is highly sensitive to heat. During summer, when temperatures exceeded 30°C, the device would automatically shut down when exposed to direct sunlight. While this issue did not affect the project's research period, it is recommended that a more integrated system is designed using a camera module directly connected to the Nvidia Jetson. This setup is more in line with industry standards for building Vision AI sensor kits.

The deployment of computer vision sensors in this project underscores the potential for integrating smart technology into urban planning. By providing high-resolution, real-time insights into public space usage, these systems can help shape urban designs that are more responsive to the needs of diverse users. The data collected also supports more inclusive planning, ensuring that public spaces are designed with safety and accessibility in mind for everyone.

In future iterations, the system could be adapted and scaled to various public spaces across New South Wales and beyond. The insights generated from this technology will be instrumental in making data-driven decisions that enhance the liveability and inclusivity of urban environments.

The application of computer vision technology in Benchmark NSW marks a significant step forward in smart urban design. By combining AI-driven data collection with privacy-preserving methodologies, this approach enables a deeper understanding of public space usage. The successful deployment in Benchmark NSW sets a precedent for future urban design projects, illustrating how ethical, smart solutions can enhance the quality of

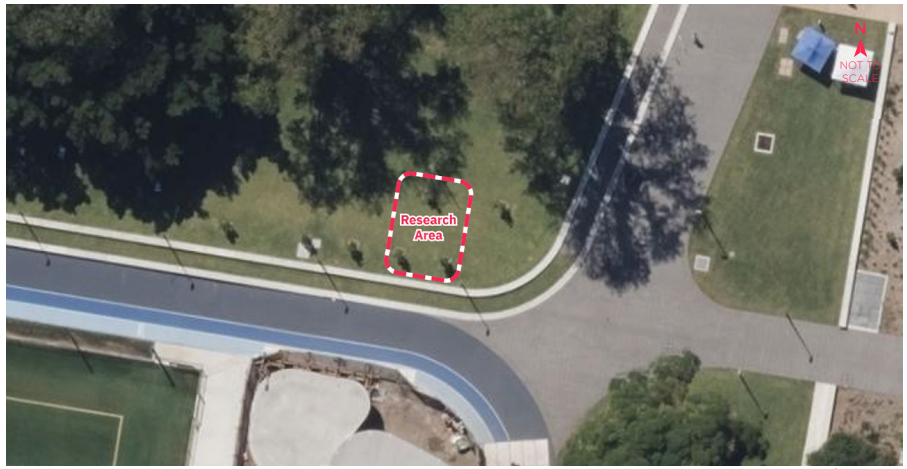
Image Credit: Robert Walsh

V. Implementation and Testing

The implementation and testing phase of Benchmark NSW was a critical component of the initiative, as it allowed the project team to gather real-world data on how the seating was used and how well it met the project's goals of promoting a feeling of safety and inclusivity. The seating was installed near the UNSW Village Green, a central public area that attracts a diverse range of users, including students, staff, and visitors. This location was chosen because of its high foot traffic and its role as a communal gathering space, making it an ideal site for observing public space usage patterns.

The testing period ran from July 4 to Aug 6, 2024, and resulted in two weeks of data with the seating installed, followed by the one week of baseline data without seating. Given the outdoor nature of project, some challenges were experienced, such as accidental power disconnection and camera disconnection from signal interferences. However, these issued were resolved within a few hours each time, minimising data loss. During the three-week testing period, temperature ranges from in between 10°C to 20°C, with 14 days of rain. Most days fell within the academic season, except for August 5 and 6, when the most student were off-campus due to a break.

Twelve benches were installed at the site, positioned to allow users to interact with them organically. Other than the information panel board and the DTPR signage, no other formal promotion or instructions were provided, as the project team wanted to observe how people naturally engaged with the seating. This approach allowed



Research Area

the team to gather authentic data on how people responded to the seating's design, functionality, and smart features.

Throughout the month, both the project team and computer vision sensors monitored public space. The sensors collected data on how many people used the seating, how long they stayed, and how they interacted with the units. In parallel, the project team also conducted intercept surveys and observational studies using adapted versions of the Evaluation Tool for Public Space and Public Life and Community Survey Tool developed by the NSW Government through the Safer Cities program. This involved observing and taking note of how many people moved through and stayed in the area, separated by assumed gender and age. These observations were made for five-minute intervals at various times throughout the day. The intercept surveys asked users a range of questions including reasons for visiting, how the benches facilitated social interaction, perceptions of comfort and longevity of stay.

Outdoor spaces are naturally subject to weather fluctuations, which can deter people from using the seating, especially during rainy or cooler days. Another challenge was the presence of large trees near the seating area, which created shading throughout much of the day. While this might have limited site activity to some extent, the conditions remained consistent over time, making them adequate for evaluating how the community co-designed benches activated the public space and enhanced social and public life.

Seating configuration left by students who socialised in the area during Benchmark NSW implementation

Sensors installed in the benches turned on the bench lighting at dusk

Benchmark NSW project information board at the project location during implementation

DTPR in-situ during Benchmark NSW project implementation

Data collection sensors in-situ during Benchmark NSW implementation
Images on Page 54-55 credit: Transport for NSW

Lessons Learnt

- **Interactive installation**

  An interactive sculptural installation at the project site was initially discussed at the early project planning stage. This intervention aimed to invite people on site to answer survey questions, which would provide an additional dataset for quantitative assessment of the gender diversity of users. This was not implemented as part of this project but it can be considered for incorporation in future iterations.

- **Challenges in observation and surveys**

  Collecting sufficient gender data through observations and intercept surveys was challenging due to the limited availability of the four Industrial Design students hired as research assistants. These students, who also contributed to the co-design of the smart seating, had to schedule their observations and surveys around their classes and campus visits, which were infrequent since most students only visit campus on class days. From July 10 to August 8, they conducted 59 five-minute observation sessions, recording a total of 198 people. However, 24 additional sessions were excluded as the recorded counts tended to be overestimated, with an average of 9 more people counted per session than by other participants. Given that the research area is a public space, each observer needed to clearly understand the defined boundaries for counting people accurately. During this period, they also surveyed 42 participants; however, the limited timeframe restricted the scope of data collection. Moreover, the timing overlapped with the final weeks of the academic term, further reducing the students' availability to gather more comprehensive data.

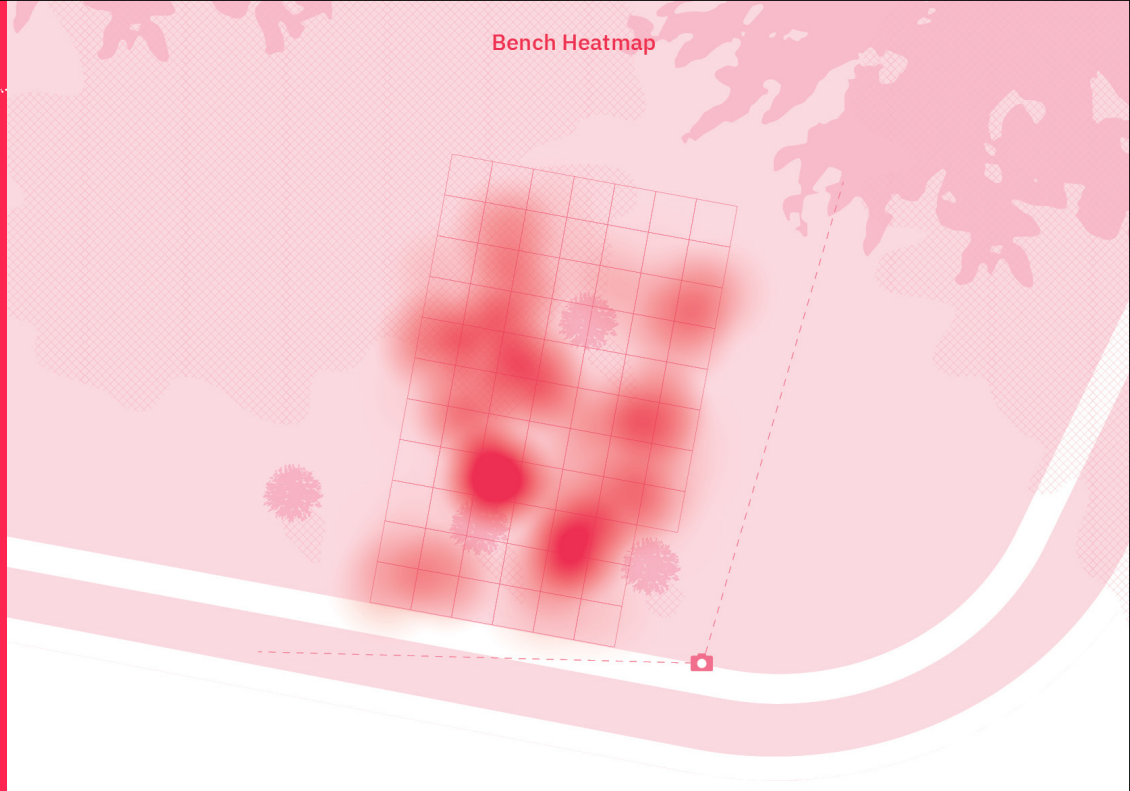
Image Credit: TfNSW

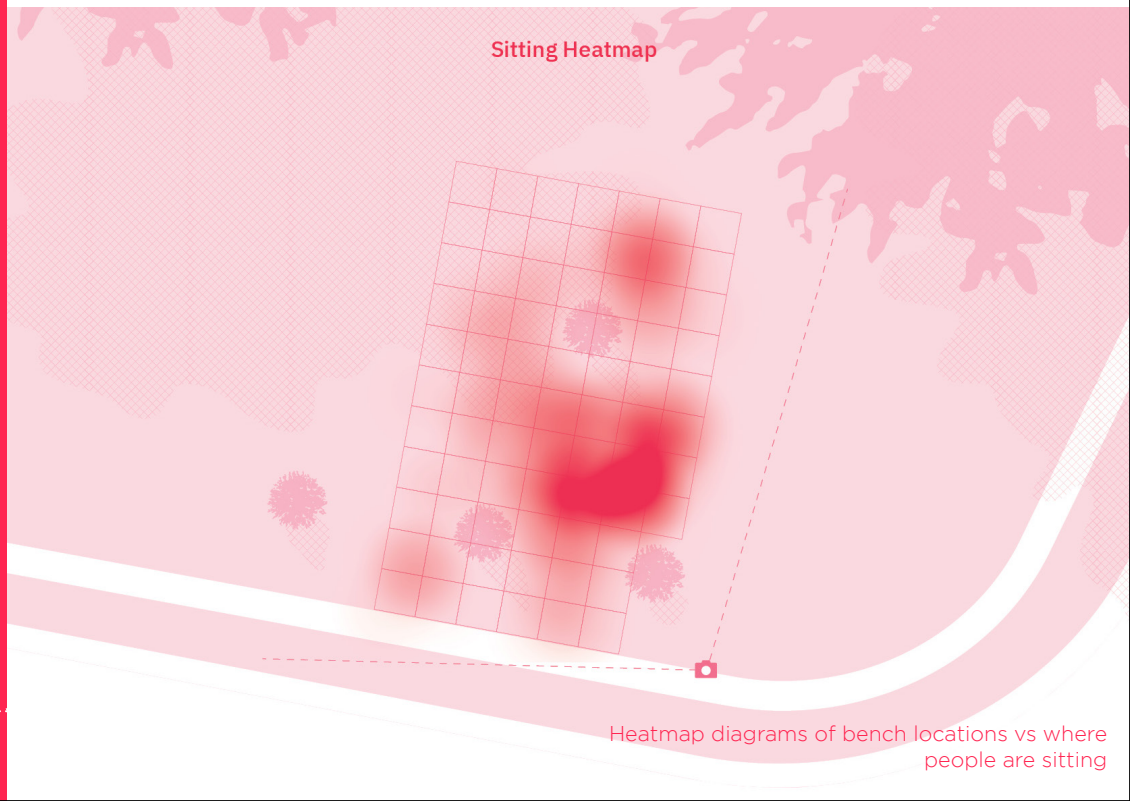
Image Credit: Robert Walsh

VI. Data Analysis

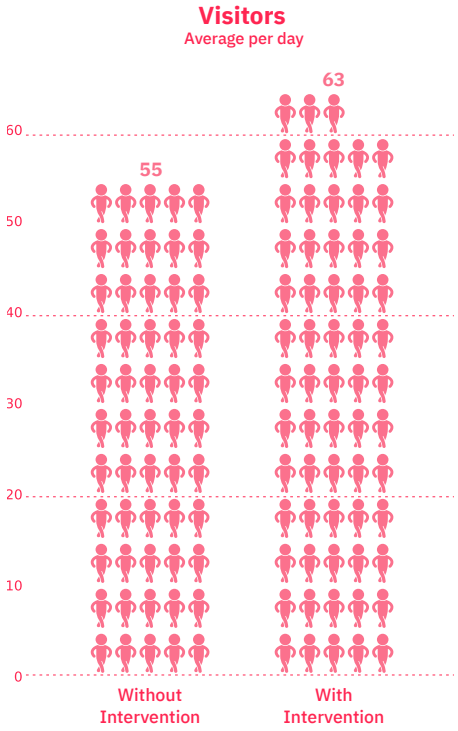
The intervention reflected the success of the project in enhancing social interaction and public space usability, particularly for women, girls, and gender diverse people. This section contains a detailed analysis of the key findings and their implications.

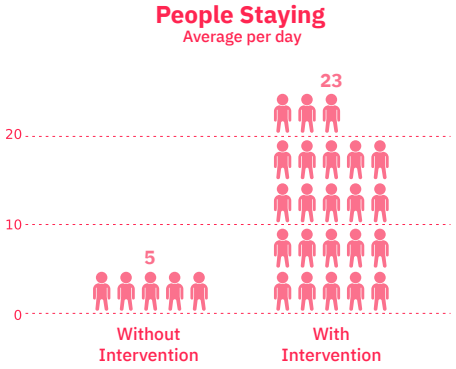
The quantitative data was collected using AI-driven computer vision technology, capturing real-time anonymised data on pedestrian flows, seating usage, and public behaviours. This data was supplemented by qualitative observations and intercept surveys conducted on-site. The sensor data was processed to measure core metrics, such as dwell time, number of visitors, social interaction, and space activation. Observations focused on understanding the behaviours and use of public space by different user groups, ensuring the findings addressed both technical performance and human-centric outcomes. These metrics were combined to assess the overall success of the intervention.

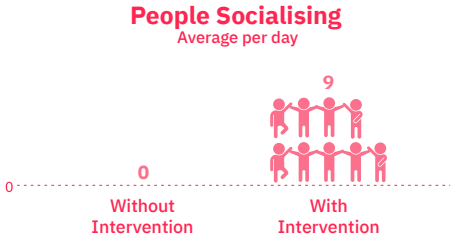


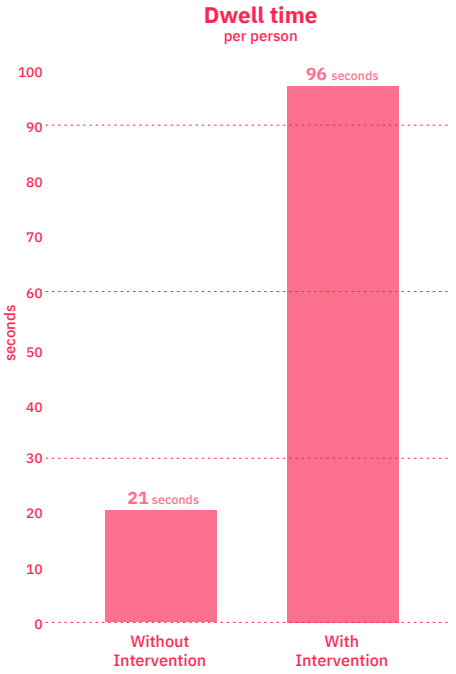


Heatmap diagrams of bench locations vs where people are sitting









Vision Sensor Data

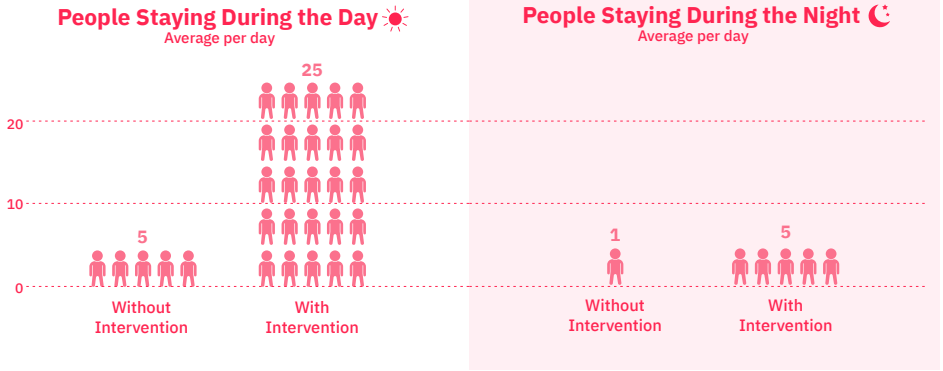
Activation of Space

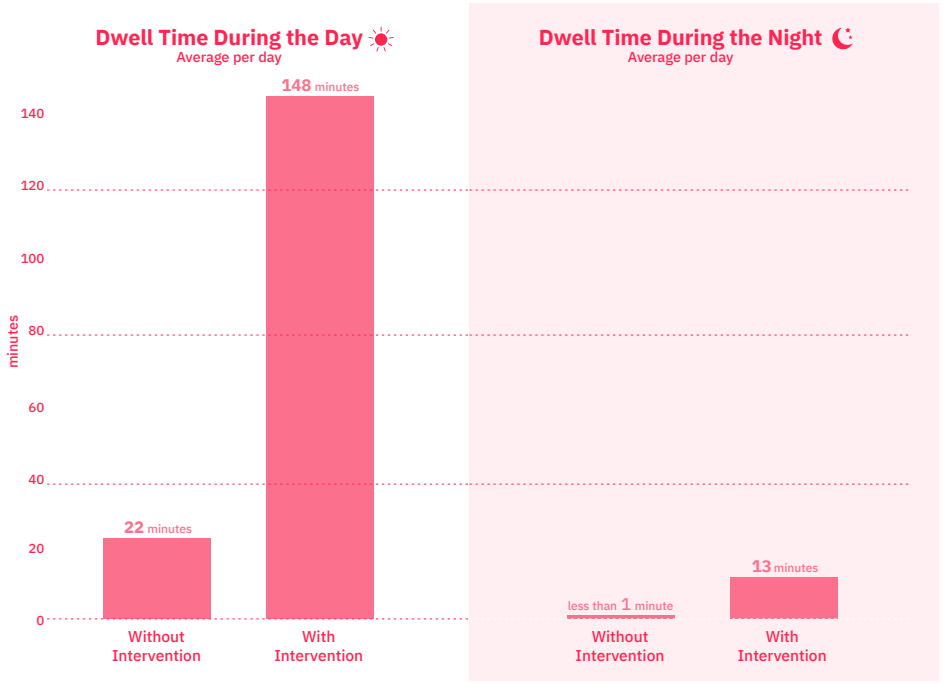
The introduction of movable seating had a significant impact on the number of people visiting and staying in the area. The data revealed a 360% increase in the average daily number of people staying on-site, rising from 5 to 23 people per day. The term ‘staying’ is defined as any individual who remained in the space for more than five minutes, indicating a deeper level of engagement with the environment. The daily number of visitors also increased by 14%, from 55 to 63 people per day. This rise in both visitor numbers and stay time illustrates how the design and flexibility of the seating made the space more appealing and functional.

In addition to increased visitation, the project also extended the amount of time people spent in the space. The total daily dwell time increased by 568%, growing from 19 minutes to 127 minutes per day. On an individual basis, the average dwell time per person saw a dramatic increase of 357%, from 21 seconds to 96 seconds per person. These figures indicate that the intervention made the public space more attractive for lingering and relaxation, fostering an environment where people felt more comfortable spending time.

Social Interaction

A key metric the project used was the count of people ‘socialising’, which was defined as people who remained within one metre of another person for more than two minutes. The baseline data showed that there were no recorded social interactions in the space without the intervention. However, when the benches were introduced in the space, the average number of people socialising per day rose to nine.





Nighttime Use and Safety

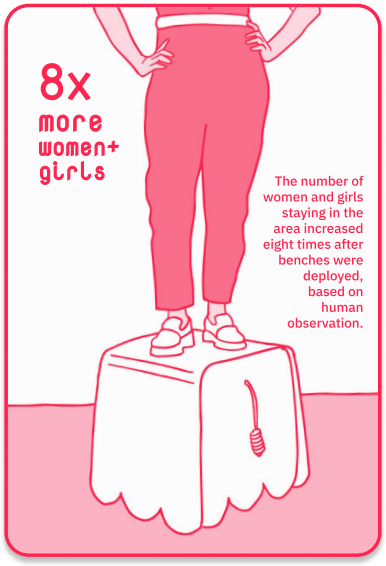
The project yielded significant improvements in nighttime use of the space, addressing longstanding concerns about safety and accessibility after dark. Utilising core indicators for the project, the team observed substantial shifts in both visitation and staying patterns during nighttime hours. Since the average sunset during the observation period was at 5:30 PM, the project defined nighttime as starting at 5:00 PM, when the area became almost entirely dark due to surrounding buildings.

Following the installation of the benches, the average total dwell time at night increased by a remarkable 7,072%, rising from 0.18 minutes to 12.91 minutes. Meanwhile, the number of people staying on-site each night surged by 583%, from 0.67 to 4.58 people per day.

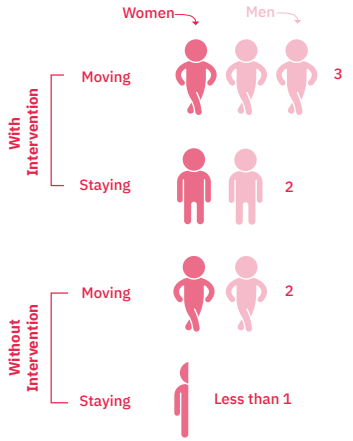
These increases suggest that the lighting integrated into the benches, along with their approachability, contributed to a greater perception of safety in the space. This was a critical success, as public spaces are often underutilised at night due to safety concerns, especially among women and gender diverse people.

Note

The AI computer vision sensor data used in this analysis was collected over a three-week period, including 19 days when classes were in session and two days without classes. To assess the impact of the non-class days, the team compared key metrics—such as the average daily visitors, average number of people staying, and average dwell time per person—across two scenarios: the full 21 days (19 class days + two non-class days) and just the 19 class days. The differences between these two scenarios were minimal. The average number of daily visitors was 53.71 for the full 21-day period compared to 54.4 for the 19 class days. Similarly, the number of people staying per day averaged 4.43 over 21 days and 4.8 over 19 days. The average dwell time per person showed a slight difference, with 0.32 minutes for the 21 days and 0.35 minutes for the 19 class days. Given these negligible differences, it was decided to include the 2 non-class days in the overall analysis.



Average people moving and staying on-site*
(per 5 minutes, rounded)



*Observation were taken during; Rush hour morning (7:00-9:00), mid-morning (9:00-11:00), midday (11:00-13:00), early afternoon (13:00-15:00), late afternoon (15:00-17:00), and early evening (17:00-19:00). Each observation lasted for five minutes. Over the three-week data collection period, a total of 59 observations were completed.

Observation and Survey

Positive Community Feedback

The community's response to the seating intervention was overwhelmingly positive. Survey respondents highlighted the approachable design and flexibility of the benches as key factors that made the space feel more inviting. Many appreciated the ability to move the benches, which fostered a sense of ownership and engagement within the community. Some comments included: "*I think it is fun to have furniture that we can move around*" and "*These chairs are more suitable for socialising.*"

Overall, 79.1% (34 out of 43) of respondents said that the seating made it easier for the public to interact socially, while 72.1% (31 out of 43) noted that the seating encouraged them to stay longer in the place.

The intervention transformed the green space into a more active, safe, and inclusive environment. The increase in the number of users, how long they stayed, and their positive comments and survey responses demonstrated the effectiveness of the design interventions.

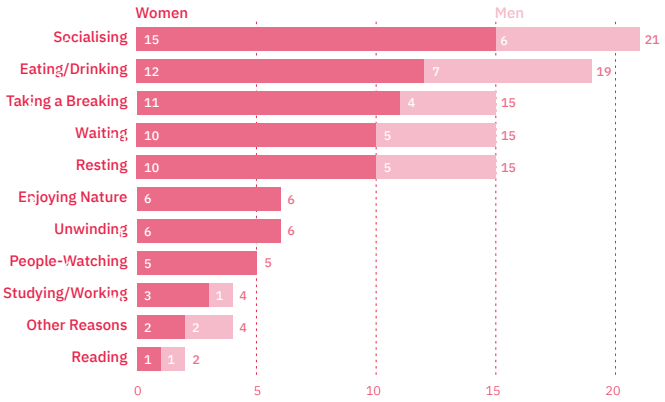
Insights from Observations

A total of 198 observations were recorded over 59 observation periods, each lasting five minutes at various times of the day, spanning from morning peak hours to early evening. Of these observations, 104 (52.5%) were identified as men and boys while 94 (47.5%) were women and girls. Moreover, 132 (66.7%) were instances of 'moving' (e.g., walking, using a mobility aid, riding a bicycle, running, jogging, using a scooter or skateboard, pushing a stroller, etc), while 66 (33.3%) were instances of 'staying' (e.g., sitting, standing, laying down, picnicking, reading, using a mobile device, etc.).

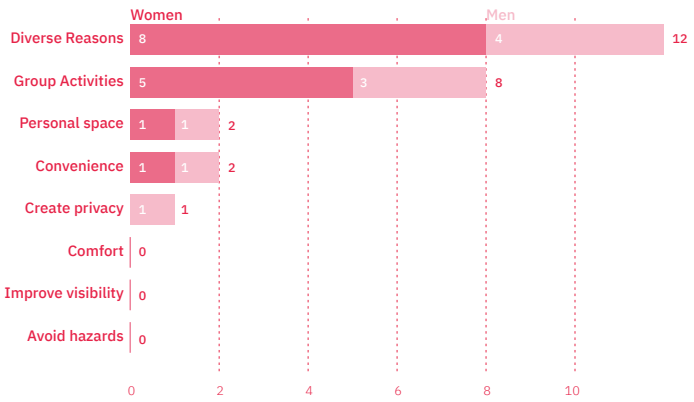
The installation of the benches led to a 1600% increase in the number of people staying per observation, rising from 0.1 to 1.6 people. The seating also had a significant impact on the staying behaviour of women and girls, with their average number rising by 800%, from 0.1 to 0.8, as well as for men and boys, the count increased from zero to 0.8.

The observed space was initially characterised by more movement than staying, but following the deployment of the benches, there was a notable increase in both total observations and movement activity. The average number of women and girls observed rose by 122%, from 0.9 to 2.0, while the count for men and boys increased by 155.6%, from 0.9 to 2.3. In terms of movement, the average number of moving women and girls increased by 50%, from 0.8 to 1.2, and the count for moving men and boys increased by 66.7%, from 0.9 to 1.5. This overall increase in both total and moving behaviours highlights that the installation of benches not only attracted more people to the space but also encouraged more dynamic activity.

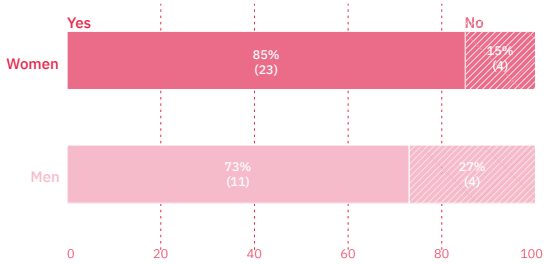
What was the purpose of your visit?



If you repositioned the benches why did you move them?



Does the seating make it easier for you to interact socially?



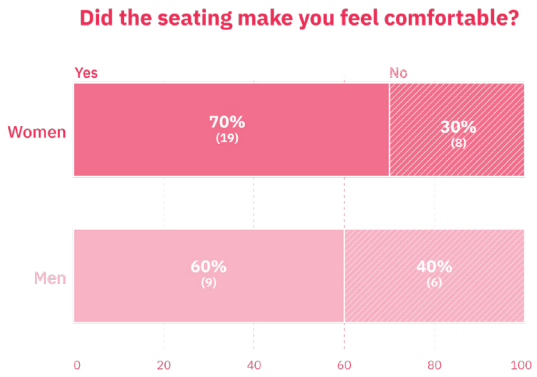
Insights from Intercept Surveys

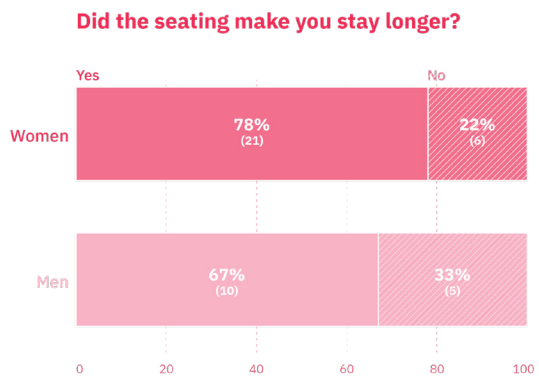
In the survey questions on reasons for visiting the space, which offer multiple answers, one notable observation is that women tend to select multiple purposes for their visits more frequently than men. On average, women chose three reasons for visiting, compared to men who selected an average of approximately two reasons. Socialising emerged as the most common reason for visiting among women, accounting for 18.5% (15 out of 81 responses). In contrast, the most frequent reason for men was eating or drinking, making up 22.6% (7 out of 31 responses). A combination of socialising and eating or drinking was particularly common among visitors, highlighting the multifunctional use of the space.

Social Interaction and Benches

Both women and men frequently repositioned the benches to better accommodate group activities, with 33.3% of women (5 out of 15) and 30.0% of men (3 out of 10) stating that they moved the seating for this purpose. Overall, the benches were seen as promoting social interaction, as indicated by the survey responses: 51.1% of participants answered 'probably yes', and 27.9% selected 'definitely yes' when asked if the seating facilitated social engagement.

However, not all respondents found the seating conducive to social interaction—nine participants (20.9%) responded 'probably not'. Despite this, a majority of 85.2% of women (23 out of 27) felt that the seating enhanced their ability to engage socially, compared to 73.3% of men (11 out of 15), indicating that the design was particularly effective in fostering social activity, especially among women.





Perceptions of Comfort

The majority of respondents felt comfortable with the seating, with 17 out of 43 responses (39.5%) indicating ‘probably yes’ and 11 responses for ‘definitely yes’ (25.5%). However, there was a segment (15 responses, 34.8%) that did not feel comfortable (‘probably not’). There is a difference based on gender for this question: 70% of women (19 out of 27) felt comfortable with the seating, compared to 60.0% of men (9 out of 15).

Longevity of Stay

The seating positively influenced the duration of stay for many respondents, with 25 indicating ‘probably yes’ (58.1%) and 6 ‘definitely yes’ (13.9%). However, 12 respondents felt it did not affect their duration of stay (‘probably not’, 27.9%). Among women, 77.8% (21 out of 27) felt that the seating made them stay longer, compared to 66.7% (10 out of 15) of men.


Image Credit: TKSW

VII. Outcomes and Impacts

Sensor Technology

The integration of advanced sensor technology significantly enhanced the project's impact. Benchmark NSW leveraged Vision AI and custom object detection models to collect precise, high-resolution data on public space usage, including sitting, standing, and social interactions around benches. By opting for vision-based recognition over other technologies like Ultra-Wideband, the project achieved reliable, cost-effective tracking without complex infrastructure. This DIY sensor kit was designed to be scalable and customisable, allowing urban planners and researchers to easily replicate the methodology in various contexts. Importantly, it adhered to privacy and transparency standards by not storing video or images.

Over a month period, the sensor kit captured valuable data, enabling the project to measure the spatial and temporal dynamics of public spaces with precision, including bench usage. These insights were crucial for understanding how urban design interventions foster social interactions, ultimately supporting more inclusive, human-centered urban planning. Moving forward, the scalable and customizable nature of this technology sets the stage for future public space projects that prioritise inclusivity, transparency, and responsiveness to community needs.

Gender inclusive Design

One of the most significant outcomes of the project was its focus on gender responsive urban design. By engaging women throughout the design process, the project contributed valuable insights into how women use public spaces and what can be done to better serve their needs. This data helped expand the body of knowledge in this field, offering practical examples of how inclusive design can lead to safer, more welcoming public environments. The emphasis of the project on elevating underrepresented voices is a critical step toward creating urban spaces that are accessible and inclusive for all users.

Interdisciplinary Collaboration

The success of Benchmark NSW also underscored the importance of interdisciplinary collaboration. Bringing together experts from UNSW, MIT, and Transport for NSW, the project leveraged a wide range of skills, from design and technology to urban planning and gender studies. This collaboration created a framework for addressing complex social issues, including perceptions of safety, inclusivity, and sustainability in urban spaces. By combining academic research with real-world applications, the project demonstrated how diverse perspectives can produce innovative solutions to longstanding challenges in urban design.

Social and Spatial Impact

In terms of social impact, the project transformed the targeted public space at UNSW into a more inviting, flexible, and engaging environment. The introduction of the modular seating led to a significant boost in social interaction and a noticeable increase in people using the space. With a nearly 420% increase in the average number of people staying per day—rising from 4.43 to 23—the project clearly demonstrated the effectiveness of well-designed public furniture in activating spaces. Additionally, the average total dwell time grew by more than 586%, from 18.55 minutes to 127.3 minutes per day. **This highlights how simple design interventions, such as movable benches, can dramatically increase the amount of time people spend in a space, fostering a stronger sense of community and engagement.**

The impact of the benches was particularly pronounced during nighttime hours, where both the number of people staying and the total dwell time increased significantly. Nighttime usage saw a 584% increase in the average

number of people staying (from 0.67 to 4.58), while the total dwell time at night surged by 7,072%, growing from just 0.18 minutes to 12.91 minutes. **These figures underscore the role that well-designed, flexible seating can play in making public spaces feel safer and more welcoming, particularly after dark.**

Sustainability and Material Innovation

The use of recycled materials in the seating design contributed to its environmental impact. By using post-consumer and post-industrial recycled HDPE plastic, the project demonstrated how waste materials can be transformed into functional, aesthetically pleasing public infrastructure. This focus on sustainability aligns with broader goals around the circular economy and shows that sustainable design can complement social responsibility. The success of these environmentally conscious materials in a practical urban setting offers a valuable example for future public space projects.

Education and Practical Experience

The project also provided hands-on experience for UNSW Industrial Design students involved in the design and fabrication of the seating. Students gained practical skills in digital manufacturing, sustainable design, and user-centred design processes. Their involvement not only enriched their education but also contributed to the overall success of the project, highlighting the value of integrating academic learning with real-world applications.

Future Opportunities

The positive feedback and measurable improvements in public space activation suggest that scalable applications of this design approach could benefit other urban environments, particularly those seeking to improve inclusivity and perceptions of safety. By expanding the scope and duration of such trials, future projects could further refine the design and measure its long-term impact on public space usage.

Image Credit: Robert Walsh

VIII. Conclusion and Recommendations

Benchmark NSW successfully demonstrated how the integration of design, technology, and sustainability can contribute to the creation of more inclusive public spaces that feel safer. Through a collaborative effort involving academia, government, and industry, the project addressed the specific needs of women, girls, and gender diverse people, while also advancing sustainability and environmental responsibility. The approach of the project serves as a model for future urban design initiatives focused on activation, inclusivity and adaptability.

Key Learnings and Impact

The data collected during the project has provided valuable insights into how different demographic groups use and perceive public spaces. These insights are crucial for informing future urban design projects, ensuring that the needs of women, girls, and gender diverse people are actively considered. The use of motion-activated lighting and computer vision technology proved effective in enhancing both safety and engagement within the public space. These technological innovations not only improved the functionality of the space but also offered real-time data collection, providing essential feedback on public space usage patterns.

By integrating smart technology with user-centred design, the project has set a foundation for replicable, scalable public space interventions that prioritise both inclusivity and sustainability. The following recommendations outline key opportunities for improving and expanding on the successes of this project in future initiatives.

Recommendations for Future Initiatives:

- **Expand the scope of testing.** The success of the seating solution at the UNSW campus suggests that future iterations should explore additional urban spaces, such as parks, plazas, and transport hubs. Testing the seating across different settings will help gather more diverse data on how various environments influence public space usage and safety perceptions. Expanding the scope of testing would allow for greater refinement of design based on the context-specific needs of different users and locations.
- **Increase community engagement.** While this project successfully engaged emerging women designers in the product design process and the community through intercept surveys, future initiatives should expand the scope of community engagement by incorporating more participatory workshops and feedback sessions. Engaging a broader segment of the community will ensure that future design solutions more accurately reflect the needs and preferences of the public. This process would provide valuable insights into how public spaces can be made even more inclusive and welcoming, fostering a sense of ownership and collaboration in the community.
- **Enhance technological integration.** The use of motion-activated lighting demonstrated the potential for further technological enhancements in public space design. Future seating designs could explore more interactive features, such as app-based controls or customisable lighting, to further engage users and enhance safety. Additionally, the incorporation of real-time data analysis could allow urban planners to make dynamic adjustments to public spaces in response to evolving usage patterns. By integrating smart technology, public spaces can become more adaptable and responsive to user needs.

- **Replicate the model in other cities.**

  The success of Benchmark NSW highlights the potential for this model to be replicated in other urban areas. Expanding these initiatives across different cities would allow for a broader impact on public space design, particularly in making cities safer and more inclusive. Collaboration with local governments, urban planners, and community organisations will be essential to tailor these projects to meet the unique needs of each location. Replicating this approach will help build a network of inclusive urban spaces, benefiting communities on a larger scale.

- **Leverage sensor data for scenario planning.**

  The data collected during the project has opened up opportunities for the initiation of a scenario planning tool that can predict changes in pedestrian flow and social interactions. This tool could be used by neighbourhood planners and community stakeholders to optimise future tactical urbanism projects. By integrating predictive analytics into the planning process, cities can better anticipate the needs of their communities and ensure that public spaces are designed to meet evolving demands.

Conclusion

Benchmark NSW successfully demonstrated the value of integrating smart technology, sustainable materials, and user-centred design to create public spaces that feel safer and are more inclusive and engaging. The project's collaborative approach, involving academia, government, and industry, provided a replicable model for other cities looking to improve their public spaces. The insights gained from this project will continue to shape the future of urban design, ensuring that public spaces become more accessible and welcoming for all. By continuing to refine and expand upon the lessons learned, future projects can build on this foundation to create vibrant, inclusive urban environments that meet the evolving needs of their communities.

Image Credit: TfNSW


Image Credit: Robert Walsh

Appendix A. Engagement and Media Summary

Engagement

Method	Date	Location Details	Participants Reached
Briefing co-designers	21 May 2024	Microsoft Teams	4 women co-designers
Initial concepts presentations	24 May 2024	Microsoft Teams	4 women co-designers
Progress presentations	28 May 2024	Microsoft Teams	4 women co-designers
Progress presentations	30 May 2024	UNSW Squarehouse	4 women co-designers
Final design presentations	3 Jun 2024	UNSW Squarehouse	4 women co-designers
Fabrication of smart seating	4 Jun to 2 Jul 2024	UNSW Design Futures Lab	N/A
Installation of computer vision sensors	28 Jun to 4 Jul 2024	UNSW Village Green	N/A
Deployment of smart seating in public space	28 Jun to 4 Jul 2024	UNSW Village Green	40 people
Observation of users of space and smart seating	10 Jul to 2 Aug 2024	UNSW Village Green	198 people observed (104 men and boys + 94 women and girls)
Intercept survey of users of smart seating	8 Jul to 2 Aug 2024	UNSW Village Green	43 people observed (15 men + 27 women + 1 preferred not to answer)

Media

Method	Date	Location Details	Participants Reached
LinkedIn Post	2 Jul 2024	LinkedIn (UNSW Industrial Design)	1,718 total video views, 798 impressions, 87 engagements, 10.9% engagement rate, 59 clicks, 24 reactions, 4 reposts
LinkedIn Post	3 Jul 2024	LinkedIn (UNSW Industrial Design)	540 impressions, 76 engagements, 14.07% engagement rate, 47 clicks, 25 reactions, 1 comment, 3 reposts
Public launch of Benchmark NSW	4 Jul 2024	UNSW Village Green	40 people
LinkedIn Post	5 Jul 2024	LinkedIn (Gisella Velasco)	119 reactions, 12 comments, 1 repost
LinkedIn Post	5 Jul 2024	LinkedIn (Brooke Wharton)	77 reactions, 7 comments, 2 reposts
Media Release	23 Jul 2024	UNSW Newsroom	531 individual page views, 254 seconds on page
LinkedIn Post	25 Jul 2024	LinkedIn (UNSW Arts, Design, Architecture)	1,358 impressions, 25 likes, 1 comment, 1 repost
Instagram Post	25 Jul 2024	Instagram (UNSW Arts, Design, Architecture)	3,957 impressions, 393 likes, 25 shares, 7 saves
Facebook Post	25 Jul 2024	Facebook (UNSW Arts, Design, Architecture)	1,556 impressions, 19 likes, 9 comments, 3 shares
LinkedIn Post	26 Jul 2024	LinkedIn (Sarah Williams)	82 reactions, 3 comments, 5 reposts
Magazine article	1 Aug 2024	Wallpaper (by Léa Teuscher; Future Publishing, Bath UK)	
Newspaper article	23 Jul 2024	The National Tribune (Toowomba QLD)	
Magazine article	1 Nov 2024	Green Magazine (Issue #100, Melbourne VIC)	

Appendix B. Intercept Survey Tool

Adapted from the NSW Government's
Community Survey Tool for Public Space and Public Life.

Benchmark NSW Survey Form

We are conducting a research study to understand how women, girls, and gender diverse people use public spaces through the implementation of smart seating. This study aims to gather insights to design more inclusive and welcoming public areas in NSW. If your age is 18 or above, we would like to invite you to participate in this research study. Are you happy to be provided with further information on the research study?

	YES, I am aged 18 or above, you may provide further information.	Proceed
	NO, I am aged below 18, please do not survey me.	Do not proceed
	NO, I am aged 18 or above but I do not want to proceed with your study.	Do not proceed

Have you participated in this survey previously?

	YES	Do not proceed. Thank them for their time. Wish them a great day.
	NO	Proceed with survey.

If you decide to take part in the research study, we will ask you to answer a few questions about your usage and perception of smart seating. It should take approximately 4 minutes to complete. During the research study, we will collect information from you relevant to this research study. Your data will be kept for a minimum of 5 years after the project's completion. Your information will only be used to analyse the impact of smart seating in public spaces. Any information we collect from you will be stored and presented in research publications in a way that will not identify you.

	YES, I am OK with this.	Proceed
	NO, I am NOT OK with this.	Do not proceed

I need a written record of your consent to participate. I will not be collecting your name or any other personal details, but I need your signature on this space to signify that you consent to participate.

If you decide to take part in the research study, we will ask you to answer a few questions about your usage and perception of smart seating. It should take approximately 4 minutes to complete. During the research study, we will collect information from you relevant to this research study. Your data will be kept for a minimum of 5 years after the project's completion. Your information will only be used to analyse the impact of smart seating in public spaces. Any information we collect from you will be stored and presented in research publications in a way that will not identify you.

	YES, I am OK with this.	Proceed
	NO, I am NOT OK with this.	Do not proceed

Please confirm that we have provided you with a verbal description of what the research involves and that you understand what your involvement in the research requires.

	YES, the research has been described and I understand my involvement is about.	Proceed
	NO, I do not understand.	Do not proceed

Is this your first time visiting this site?

	YES, this is my first time.
	NO, I have been here before the new seats were put in place.
	NO, I have been here after the new seats were put in place

If it's not your first time, when do you usually come here?

	More in the daytime
	More in the nighttime
	Equally both
	Required to answer. Single choice.

What brings you here today? (select all that apply)

	Resting
	Socialising
	Studying or working
	Waiting
	Eating or drinking
	Reading
	People-watching
	Enjoying nature
	Taking a break from other activities
	Unwinding or de-stressing
	Other, pls specify

If you've been here since the new benches were put in place, did you move around those benches?

	YES, I repositioned the benches.
	NO, I did not reposition the benches.

If you repositioned the benches, why did you move them? (select all that apply)

	To better accommodate group activities
	To maintain personal space or distance from others
	To enhance environment comfort (e.g., less noise, more sunlight)
	To create a more private or secluded area

	To improve visibility or line of sight
	To make the space more accessible or convenient
	To avoid obstacles or hazards
	Other, pls specify

How much time do you plan on spending here today?

	Less than 5 minutes
	5 to 10 minutes
	11 to 30 minutes
	31 minutes to 1 hour
	Longer than 1 hour

Who are you here with today?

	Alone
	With someone else (pair)
	With 3 of my friends or colleagues
	With 4 of my friends or colleagues
	With 5 of my friends or colleagues
	With children and/or other family

Would you come here alone?

	YES, I would come here alone at any time.
	YES, I would come here alone but only during the day.
	YES, I would come here alone at night.
	MAYBE, I'm not sure if I would come here alone.
	NO, I would never come here alone.

Does the seating make you feel more comfortable in this place?

	Definitely YES.
	Probably YES.
	Probably NOT.
	Definitely NOT.

Does the seating make you stay longer in this place?

	Definitely YES.
	Probably YES.
	Probably NOT.
	Definitely NOT.

INTERACTION: Does the seating make you feel more comfortable in this place?

	Definitely YES.
	Probably YES.
	Probably NOT.
	Definitely NOT.

What is your age group?

	18-24
	25-34
	35-44
	45-54
	55-64
	65-74
	75 and above

Which of these genders best describe you?

	Man/male
	Woman/female
	Non-binary
	I use a different term (ask what term)
	Prefer not to answer

Do you have any suggestions for improving the safety or usability of this seating?

If you could change anything about this public space, what would it be?

Thank you for your time. Have a great day!

Appendix C. Observation Tool

Adapted from the NSW Government's
Evaluation Tool for Public Space and Public Life.

Benchmark NSW

Observation Tool: Snapshot of People

Tally the number of people = 5 people 

Use this table to count how many people are moving through or staying in the space for five minutes. To get an hourly average, multiply the total amounts by twelve. Approximate each person's age group. Tally everyone together in the Mixed column, or if you feel comfortable, you can tally them by Male or Female, approximating their gender based on their visual appearance. Refer to the project site to help define the area you are counting people in. Conduct observations during one of the following times each day to capture a representative sample of usage patterns:

	07:00-09:00 Rush Hour Morning		01:00-13:00 Midday		15:00-17:00 Late Afternoon
	09:00-11:00 Mid-Morning		13:00-15:00 Early Afternoon		17:00-19:00 Early Evening

Moving

People walking, using a wheelchair, riding a bicycle, running, jogging, using a scooter or skateboard, pushing a stroller, etc.

MOVING	Male			Female			Other		
Age group	Tally	Total	Hourly	Tally	Total	Hourly	Tally	Tonal	Hourly
Child (0-12)									
Teen (13-17)									
Yound Adult (18-24)									
Adult (25-64)									
Senior (65+)									

Staying

People sitting, standing, laying down, leaning against surfaces, picnicking, reading, using a mobile device, etc.

STAYING	Male			Female			Other		
Age group	Tally	Total	Hourly	Tally	Total	Hourly	Tally	Tonal	Hourly
Child (0-12)									
Teen (13-17)									
Yound Adult (18-24)									
Adult (25-64)									
Senior (65+)									

Name of observer					
Date of observation		Start time		End time	
Weather at time of observation					

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