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SHORT-PAPER

QRPATH: Evaluating QR Codes as an Alternative to Human Observation in Physical Space Wayfinding Studies

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QRPATH: Evaluating QR Codes as an Alternative to Human Observation in Physical Space Wayfinding Studies

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Abstract

This research investigates the practicality of automated data collection methods as an alternative to human observation in physical space wayfinding studies. Traditional approaches for capturing foot traffic and navigational behavior are often labor-intensive and resource-demanding. To address these challenges, we conducted a study assessing the feasibility of using QR codes to collect observational data. Thirteen participants navigated a national public library while their movements were tracked through strategically placed QR codes and concurrently by human observers. Analysis revealed that QR codes offer comparable precision in recording navigational data while potentially reducing the need for human labor. However, issues such as missed scans, environmental constraints, confusion with unrelated codes, and the absence of contextual insights suggest that while QR codes may enhance observational research in public settings, they should be integrated with traditional methods rather than serving as a complete replacement.

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CCS Concepts

• **Human-centered computing**; • **Human computer interaction(HCI)**;

Keywords

Observational studies, QR codes, user engagement, data collection, navigation systems, user behavior

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1 Introduction

Studying how individuals navigate physical environments [13] informs researchers about people's interaction with spatial information objects and systems [8]. Examining navigational paths, observed behaviors, and points of difficulty or delay enables researchers to identify user needs [4], preferences, and the effectiveness of both spatial design and navigational aids such as signage, printed maps, or mobile applications [15]. *Wayfinding research* [29] also reveals areas of uncertainty, congestion, or high traffic that inform the optimization of spatial layouts [1] and the design of information systems embedded in physical spaces [6]. These insights support data-driven decision making for creating environments that better support orientation, access, and movement, aligning physical infrastructure with users' informational and navigational expectations.

However, observational studies in physical environments are often resource intensive, requiring extensive participant monitoring, on-site fieldwork, and complex data management and analysis processes. These demands can lead to inefficiencies in how organizations allocate resources [14]. The dependence on human observers, who may not always be available, and the potential for observer bias [28] further emphasize the need for scalable, reliable alternatives. Emerging digital and online methodologies present opportunities for enhancing data collection in physical contexts [5, 26], as these technologies can help streamline observational workflows, reduce manual overhead, and potentially generate richer, more actionable insights.

A developing focus within Human-Computer Interaction (HCI), spatial cognition, and other fields is on hybrid observational methodologies that combine automated systems and human observation [5]. These mixed-method approaches may offer deeper insight into user behavior (UB) by integrating precise movement data with contextual observations. From an HCI perspective, there is a need to balance the efficiency of automated data collection with the interpretative depth of qualitative methods when studying navigation and spatial interaction [12]. A useful technology to address this balance might be *Quick Response* (QR) codes, which are two-dimensional barcodes that can be scanned using smartphones and similar devices to access embedded content, such as URLs or digital forms [23, 27]. Researchers have explored a range of applications for QR codes, particularly in linking physical environments with digital information systems [10, 16, 18, 20]. This study investigates the potential of QR codes to streamline data collection in observational research. As part of an initiative to enhance the usability and accessibility of a national library (NL) map [21], we compare the use of QR codes with traditional human observation for tracking foot traffic in a physical space [2, 24]. This methodological comparison evaluates whether QR codes can simplify or accelerate data collection processes while addressing common limitations in conventional approaches.

The current study assesses the ability of QR codes to produce accurate, efficient, and user-friendly navigational insights through the following research questions (RQs):

- ***RQ1:*** *In what ways does the data gathered through QR code-based tracking compare to data collected via traditional human observation for analyzing foot traffic in a physical information environment?*
- ***RQ2:*** *To what extent can QR codes serve as an effective method for evaluating the use and performance of a navigational aid within a physical information setting?*

Our analysis provides findings concerning capturing visitor navigation behaviors and preferences through QR code-based tracking, along with a comparative analysis of this method against traditional human observation. It also identifies the types of unique data QR codes can yield and examines user experience (UX) considerations are associated with their use in physical environments. Findings contribute to ongoing efforts to enhance data collection practices related to spatial navigation and inform strategies for improving user-centered design (UCD) in public spaces. The following sections detail the study's methodology, including the research design, survey instruments, and participant demographics, followed by results from the observational and QR code data. The paper concludes with a discussion of key findings and implications for future research.

2 Methodology

2.1 QRPath Insights: Leveraging the METRIC System for Spatial Data Collection

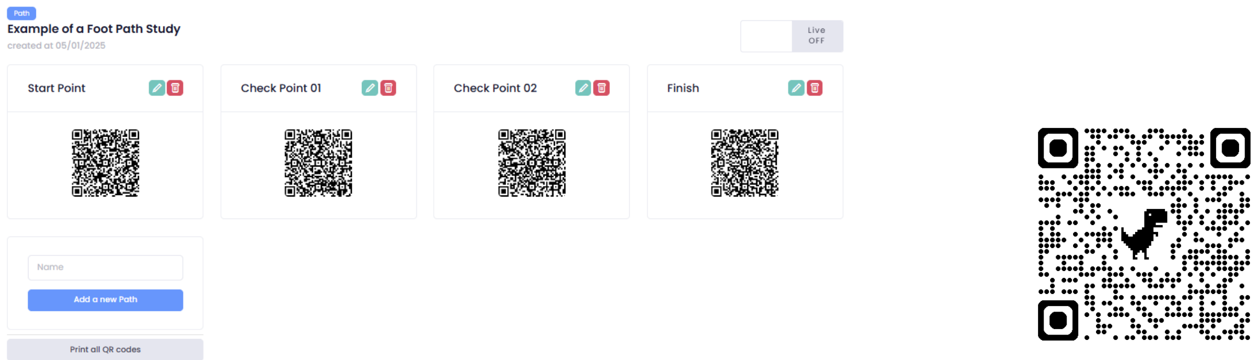
METRIC [3] is a web-based research platform that supports data collection, analysis, and reporting of participant engagement across both physical and digital environments. Designed to support a variety of research contexts, METRIC offers flexible tools for capturing interaction data, enabling a more comprehensive understanding of UB. This study applied METRIC's *QRPath Insights* feature, which logs participant interactions with strategically placed QR codes and integrates online survey responses. The setup is designed for ease of deployment. QR codes are generated as unique identifiers within METRIC and assigned to specific locations along predefined paths of interest (see Figure 1a). These codes are then printed and installed throughout the physical study environment. METRIC is openly available at https://metric.qcri.org (see Figure 1b).

Each QR code in the QRPath system can be linked to a survey hosted on platforms, such as Qualtrics, Google Forms, or SurveyMonkey, enabling the collection of demographic data, emotional responses, and user feedback at specific points during navigation. As participants move through the physical space and scan the QR codes, their interactions are logged in real time within the METRIC interface, providing researchers with immediate or retrospective access to participant trajectories (see Figure 2). The resulting QRPath supports a range of applications, including the identification of efficient routes, enhancement of signage design (e.g., font size, visibility, placement), detection of high-traffic zones, and the improvement of spatial representations, such as maps.

3 Participants, Data Collection Methods, and Study Design

3.1 Participants

Participants were recruited from visitors to the N who volunteered for the study, all of whom owned smartphones capable of scanning QR codes. The study sample consisted of thirteen individuals, spanning an age range of 18 to 64, with the majority aged 18–34. The gender distribution was nearly balanced, comprising seven male (53.8%) and six female (46.2%) participants. Most participants (n=8, 61.5%) were repeat visitors to the NL, and over half (n=7, 53.8%) reported visiting the library on a weekly or daily basis. Their primary motivations for visiting included studying (n=6, 46.2%), leisure reading (n=4, 30.7%), research (n=3, 23.1%), and attending events (n=2, 15.4%). Interestingly, ten participants (76.9%) had not previously used the NL map for navigation, suggesting a general lack of awareness or non-reliance on this navigational resource.



(a) QR codes for designing a footpath study with four checkpoints

(b) METRIC QR code

Figure 1: (a) Example sequence of QR codes deployed in a QRPath study using the METRIC system; (b) QR code linking to the METRIC platform interface

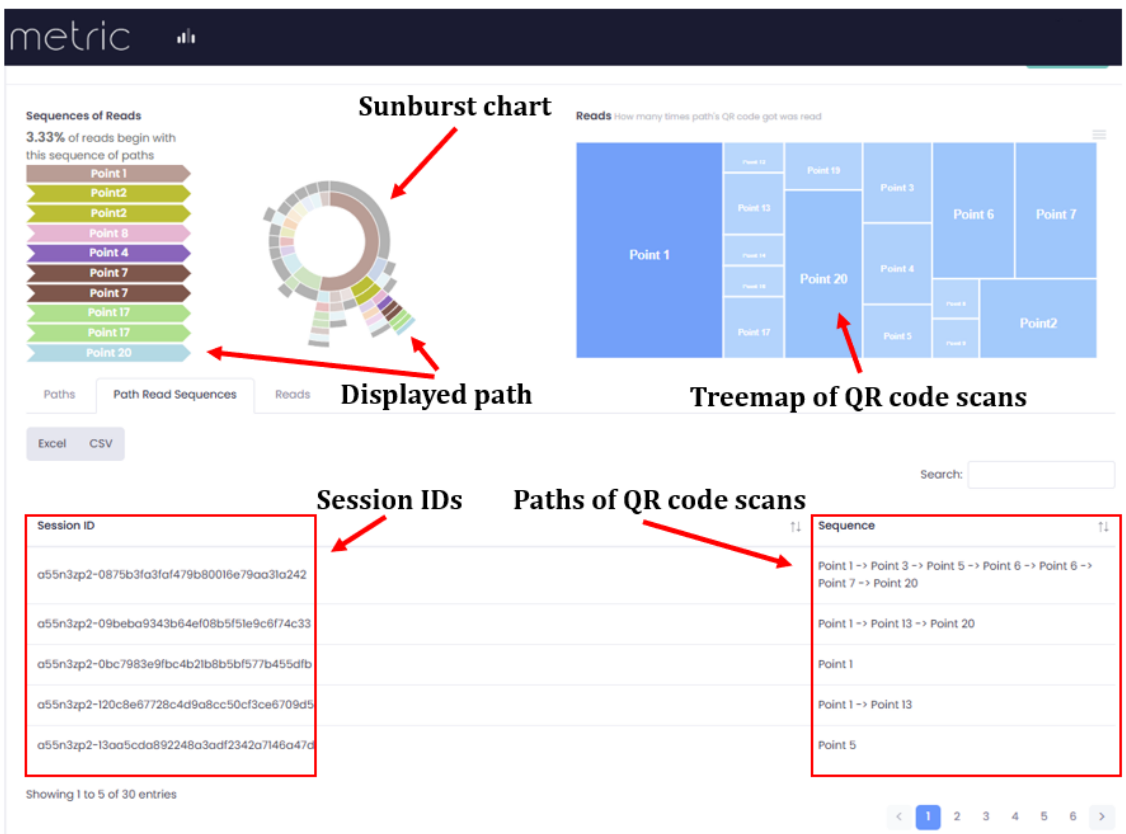


Figure 2: Sample QRPath Insights analytics generated by the METRIC system, including an interactive sunburst chart, treemap, session identifiers, and visualizations of navigation paths by session

Although the sample size for this study was small (n=13), the primary objective of the study was to assess the feasibility of integrating automated data collection methods with traditional observational approaches and to explore methodological trade-offs, rather than to produce generalizable findings. The absence of a formal hypothesis is consistent with the study's exploratory design, with RQs guiding the comparative analysis of automated versus manual tracking methods. Accordingly, the study's conclusions reflect its exploratory nature. For example, we report that QRPath demonstrated comparable timing precision to human observation; however, it did not capture the full spectrum of participant behavior. Future research can build on these preliminary insights by

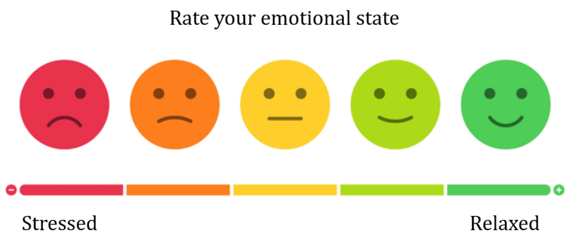


Figure 3: Smiley face rating scale used by participants to provide quick emotional feedback at each intermediate QR code checkpoint

employing larger samples, incorporating control conditions, and applying more robust statistical methods to support the broader applicability and practical implementation of automated methods for such studies.

3.2 Data Collection Methods

Participants started the study by scanning the first QR code located at the NL information desk, which linked to a consent form and an initial questionnaire. A second questionnaire was completed at the final QR code that was placed at the designated ending destination. The initial survey collected demographic details, such as name, age, and gender, as well as information on participants' wayfinding behaviors, including their comfort navigating unfamiliar environments, preference for signage versus verbal assistance, and self-assessed sense of direction. It also gathered data on previous navigation experiences within the NL. The endpoint questionnaire captured UX data and emotional responses related to the navigation task. To supplement this, brief reaction surveys were embedded in intermediate QR codes along the path, using a smiley face scale (see Figure 3) [6, 10], which provided lightweight emotional feedback at key navigation checkpoints.

Each participant navigated the environment individually, without interacting with other participants. Although they occasionally shared space with other visitors, no group-based navigation occurred. The METRIC system assigned a unique session ID to each participant's device at the first scan, enabling simultaneous participation without data overlapping. This ensured distinct, traceable navigation paths even in multi-user scenarios. METRIC's device-based tracking supports concurrent users without altering QR code placement.

3.3 Study Design

Participants were assigned a navigation task designed to evaluate the usability of the NL map. They were instructed to locate the *Technology Section* (TZone), a frequently requested but challenging destination, starting from the information desk. This task aimed to highlight potential issues in the map's design and functionality, thereby supporting an evaluation of the map's effectiveness as a navigational aid. Findings would inform recommendations for improving the map to ease the burden on information desk staff and enhance the overall UX. The TZone was selected in consultation with the NL's subject matter experts (SMEs), who identified it as the most common source of directional inquiries from library visitors, and visitors frequently struggled to locate this section. Embedding the study within a realistic task addressed this concern while maintaining ecological validity of using real UX [17, 19].

Five primary navigation paths were identified for the study (see Figure 4), with twenty designated locations along these routes selected for QR code placement (see Table 1 and Figure 4). These QR codes were positioned to map the journey from the information desk (Point #1) to the TZone (Point #20). The initial QR code at the information desk directed participants to the consent form and demographic survey, while the final QR code at the TZone linked to a feedback and satisfaction survey. Staff at the information desk used a standardized recruitment script and provided no additional navigational guidance during the task. The NL map evaluated during the study was a single-floor schematic designed to help users locate various book sections (see Figure 4).

To support comprehensive data collection, a multi-observer protocol was employed. One observer utilized the METRIC system to monitor participant activity in real-time, ensuring the accurate logging of QR code interactions. A second observer was stationed at the information desk to welcome participants and administer the initial instructions. A third observer followed participants at a distance, discreetly recording their navigation behaviors and deviations. This triangulated approach enabled the cross-validation of METRIC data with in-person observations, allowing for the identification of qualitative insights not captured by the QR code system alone.

Although the study did not include a traditional control group, it employed a mixed-methods approach, concurrently tracking all participants through both QR code scans and human observation [9]. This dual-data collection strategy enabled a direct comparison between automated and manual observation, allowing researchers to identify discrepancies, assess the accuracy of QRPath logs, and capture additional qualitative insights into participant behavior. This parallel tracking approach yielded comparative insights that clarify the advantages and limitations of QRPath as a supplementary, rather than standalone, observational tool. The use of automated and human tracking provided a practical means of evaluating QR code performance under real-world conditions.

4 Findings

4.1 RQ1: In what ways does the data gathered through QR code-based tracking compare to data collected via traditional human observation for analyzing foot traffic in a physical information environment?

To address RQ1, we compared the timing data from the QR code-based approach with that of the observational approach (see Table 2).

Participants spent an average of approximately 12 minutes and 5 seconds completing the navigation task. Sixty-four percent of the participants completed the task in under 15 minutes, while the remaining participants required between 15 and 24 minutes to complete it. The shortest completion time, about 2 minutes, occurred when a participant bypassed most of the QR codes and navigated directly to the destination. As shown in Table 2, one notable outlier

Table 1: Expected participant navigation paths and corresponding sequences of QR code checkpoints (CP) from the information desk to the TZone

Path Number	QR CP Sequence
1	CP1 → CP2 → CP3 → CP5 → CP6 → CP7 → CP20
2	CP1 → CP2 → CP8 → CP4 → CP5 → CP6 → CP7 → CP20
3	CP1 → CP2 → CP8 → CP9 → CP10 → CP11 → CP20
4	CP1 → CP13 → CP14 → CP16 → CP17 → CP20
5	CP1 → CP13 → CP15 → CP6 → CP7 → CP20

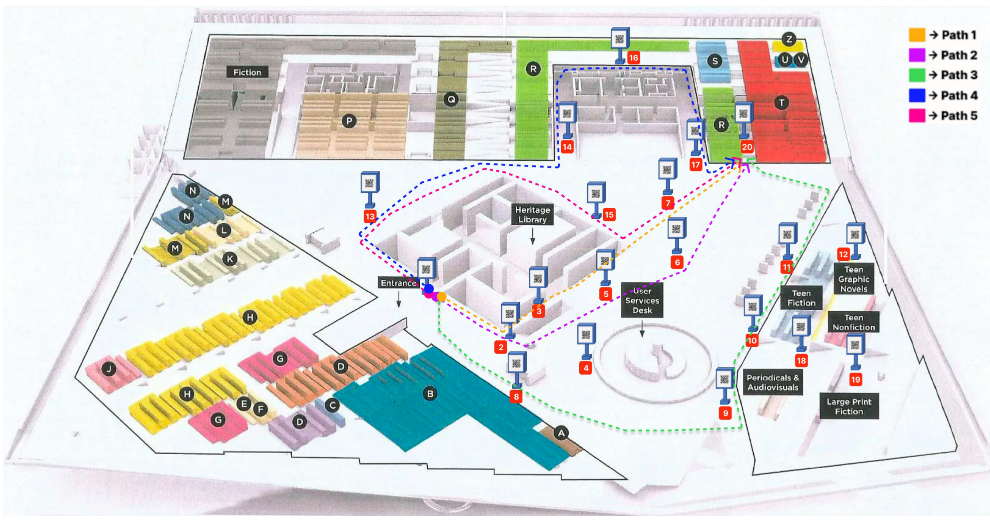


Figure 4: NL floor map with QR code placements. Five navigation paths are identified from the information desk to the targeted TZone section

Table 2: Comparative analysis of time-based data collected through human observation and the QR code (QRPath) system during the navigation task

Time Metric (minutes)	From Observation (O)	From QRPath (QR)	Difference (O-QR)
average (min)	18.33	12.05	6.28
median (min)	12.33	12.49	-0.16
maximum (min)	71.17	23.72	47.45
minimum (min)	3.95	2.03	1.92

in the observational data recorded 1 hour and 11 minutes due to unrelated activities outside the study. In contrast, the QR code system accurately logged this participant's restart time at 24 minutes, reflecting only task-relevant engagement. These variations in completion time illustrate the diversity in participant UB and interaction styles. While QR codes provided precise timestamped data, interpreting the reasons behind these differences, such as distractions or noncompliance, relied on insights gained through human observation.

When the outlier is excluded, or substituted with the participant's second recorded session of 24 minutes, the timing data from the QR code-based system and the observational method align closely. However, while the QRPath system offers strong precision and automation benefits, it does not capture the qualitative dimensions of UX, such as behavioral patterns, navigation difficulties, or situational context. Although some of this context was elicited through participant surveys embedded in METRIC, these self-reports lacked the depth and immediacy provided by in-person observation.

Although the QR codes offered accurate quantitative data at each scan location, the observational approach uncovered several qualitative insights related to participant experience and navigational challenges. Despite its visual appeal, the map exhibited several usability issues, including misalignment with physical landmarks,

Table 3: Frequency of scans recorded at each QR code checkpoint along the designated navigation paths

Point(s) (QR Codes)	Number of Check-ins
1	18
20	14
2	7
6, 7	6
19	5
3, 4	4
5, 9, 10, 17	3
12, 13, 16, 18	2
8, 11, 14	1
15	0

inconsistent labeling, and a lack of representation for spatial features such as bridges and blind spots—all of which contributed to participant confusion. Observers noted, for example, that inconsistencies in the layout and labeling of the NL map frequently confused participants, prompting some to take longer and more circuitous routes than expected, despite their METRIC-recorded paths appearing direct (see Table 3). These observational insights were critical for interpreting discrepancies between logged navigation data and actual user behavior.

The METRIC system *QRPath Insights* automated the tracking of participant movement by logging scan frequencies at each checkpoint and reconstructing individual navigation paths, effectively removing the need for manual tracking. However, the system could not capture the details behind participant decision-making and navigational challenges. While QR codes efficiently capture quantitative path data, they fall short in providing the contextual richness that in-person observation affords. Critical qualitative insights, such as user hesitation at key decision points, confusion triggered by ambiguous signage, or subtle nonverbal cues of frustration, were essential for interpreting participant UB and could not be reliably obtained from self-reported questionnaires alone. Although surveys embedded in *QRPath Insights* captured general sentiment, they lacked the granularity and spontaneity that trained observers were able to document. Therefore, QR-based systems are insufficient for capturing the depth of UX without complementary qualitative methods.

Survey data recorded participant reactions to using QR codes, providing UX feedback from all 13 participants during their navigation task. Emotional responses varied: 38.5% (n=5) reported feeling confident and relaxed, 23.0% (n=3) expressed confusion, and 7.6% (n=1) experienced frustration. Overall, 46.1% (n=6) rated their emotional experience as highly positive, and more than half (53.8%, n=7) reported no stress. Confidence in wayfinding varied as well, with 23.1% (n=3) expressing moderate confidence and 15.4% (n=2) indicating very high confidence in their navigational ability. These findings suggest both the potential and the limitations of QR codes as navigational aids. Most participants (76.9%, n=10) found the QR codes easy to use, and frustration was low. However, some participants reported usability issues, such as ambiguous labels and lag during page loading, indicating opportunities for improving the implementation of QR-based systems in physical navigation contexts.

The survey findings closely mirrored insights gathered through observation. Participants who reported higher levels of confidence were generally able to reach the destination more efficiently. At the same time, those who expressed confusion often took longer due to misinterpreting the map and taking detours to incorrect locations. Although the map was perceived as visually appealing by many, participants consistently identified issues with clarity and labeling, which hindered effective navigation. Many participants indicated that revisions to the map's design and labeling conventions were needed to improve its utility as a navigational aid within the library setting.

4.2 RQ2: To what extent can QR codes serve as an effective method for evaluating the use and performance of a navigational aid within a physical information setting?

In response to RQ2, QR codes were effective in supporting the evaluation of a navigational aid, in this case, the NL's map. Most participants consulted the map prior to beginning the task, with some using it to identify nearby landmarks and orient themselves within the space. Throughout the task, many participants continued to refer to the map to locate points of interest, such as the café or the help desk. These interaction patterns revealed insights about how users engaged with the map; however, such UBs were only observable through human observation. These contextual observations, such as when and how participants referred to the map, would not have been captured through QR code interactions alone, underscoring the need for complementary observational methods when evaluating the effectiveness of spatial information tools.

Participants followed different navigation paths depending on which area they first identified on the map. For example, those who initially located the user help desk were frequently guided along Path 2 or 3 (see Table 1 and Figure 2), which led them to the Teen's Novel section instead of the intended TZone. A key observation was that participants often became so focused on interpreting the map and finding their destination that they overlooked scanning several QR codes. While *QRPath Insights* typically reflected four to five scans per participant, direct observation confirmed that many participants walked past additional codes without engaging them. This discrepancy suggests that automated tracking may miss important UBs and decision points.

Post-session survey responses indicated that participants rated the map's accuracy as moderate, with responses distributed across the evaluation scale. While 46.1% (n=6) found the map helpful, opinions on its level of detail and visual appeal were mixed. Specifically, 38.4% (n=5) rated the detail level as very high and viewed the design favorably. However, participants also indicated the map's lack of alignment with the actual library layout. Although some users found it helpful in locating general areas, many called for improvements in clarity, instructional content, and structural correspondence. Figures 5 and 6 illustrate participants' confidence in using the map and their perception of its accuracy. Notably, several

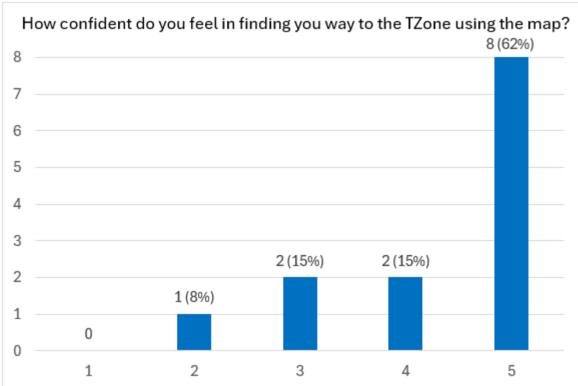


Figure 5: Participant self-reported confidence levels in using the NL map for navigation

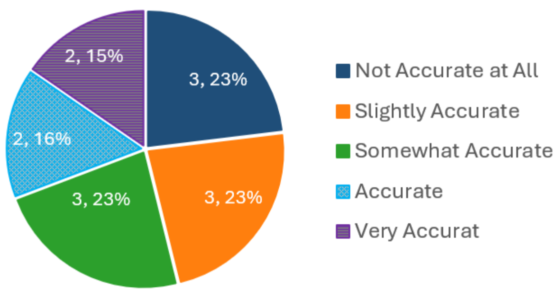


Figure 6: Participant perceptions of the NL map's accuracy for reflecting the physical layout

critical comments emerged despite initially positive ratings, revealing a disconnect between first impressions and actual navigation experiences.

The study surfaced limitations of the QR code-based approach. Missed scans, challenges related to map interpretation, and participants' reliance on external cues demonstrate that QR codes alone were insufficient for capturing the full range of navigation behaviors or producing the depth of insight required for meaningful evaluation. Few participants successfully followed the intended Path 1 to reach the TZone (see Table 1); most instead followed Path 3, which directed them toward a bridge. Notably, no QR codes were placed on the bridge, and observers reported that participants frequently became disoriented at this juncture. Some disregarded the map and navigated by memory, while others relied heavily on it, often with limited success. The bridge, a non-collection space used primarily for computer access, became a point of confusion for many. These observations revealed that several participants scanned fewer than three QR codes throughout their journey. Crucially, the qualitative insights that enabled a deeper understanding of these UBs arose from the parallel observational study. Without this complementary method, the data collected via QR codes would have been too limited to support robust analysis.

These findings suggest that a core limitation of a QR codes approach is its dependence on participants to actively engage with the system by scanning the QR codes. This action can be obtrusive, interrupting the natural flow of movement and potentially influencing decision-making during navigation. Such disruptions are particularly problematic in usability evaluations, where imposed pauses may obscure authentic navigation patterns or introduce artificial hesitation. In contrast, human observation offers the advantage of capturing spontaneous behavior unobtrusively, preserving the integrity of natural interaction. These behavioral distortions must be considered when interpreting data from QR-based methods, especially in contexts where continuous, uninterrupted spatial reasoning and movement are essential to understanding UX.

Although the navigation map provided essential context for situating the study within a realistic task, the core aim of this research was to evaluate the viability of QR codes as a method for collecting observational data. As such, findings related to the map's usability and accuracy are included not as primary outcomes, but as illustrative examples of the types of UBs that QR codes can, and cannot, effectively capture. The emphasis on participant interaction with the map is intended to expose the limitations of automated tracking when used in isolation. Future research could expand the applicability of the QR code method by examining alternative task contexts that are not anchored to specific navigation tools, enabling broader generalization of this observational approach.

5 Discussion

This study presents several strengths that contribute to ongoing research regarding the automation of data collection in physical environments [11]. It addresses a timely research question, aligned with broader initiatives aimed at reducing the labor demands of observational research through the adoption of digital technologies. A key contribution lies in its novel comparative approach that integrates QR codes into a research platform (METRIC *QRPath Insights*) and evaluates their performance with traditional human observation. Conducting this comparison under real-world conditions provides insight into the trade-offs between automated and manual methods.

Theoretically, this study contributes to an emerging body of research on hybrid observational methodologies by demonstrating how automated tools, such as QR codes, can be integrated with human observation to address both quantitative and qualitative dimensions of UB in physical information environments [21, 25]. It extends discussions in HCI around the trade-offs between efficiency and contextual richness in data collection. Practically, the findings offer guidance for institutions seeking scalable, low-cost methods to study user navigation and spatial interaction [22]. While QR codes can streamline data collection, they should be deployed alongside observational techniques to ensure comprehensive insights, especially in settings where UB is highly variable or context-dependent.

Investigating the use of QR codes for wayfinding research in a physical setting, the study identified several limitations that impacted the quality and completeness of the data collected. Although QR codes showed promise for automating aspects of navigational tracking, such as recording time stamps and path sequences, they did not eliminate the need for human observers. Human involvement was essential to ensure that participants scanned the correct QR codes, interpreted behaviors in context, and troubleshooted technical challenges. For instance, participants frequently bypassed intermediate QR codes while concentrating on reaching the destination or interpreting the map, resulting in partial datasets. Even with five predefined routes, participants often diverged from expected paths, explored unrelated areas, or scanned external QR codes, introducing inconsistencies in the tracking data. Such variability is indicative of the difficulties in capturing user behavior in unscripted environments. Additionally, the METRIC system encountered technical issues, including occasional failures to log scans and the creation of multiple session IDs for individual participants, which required manual post-processing to reconcile data and reconstruct navigation sequences. So, technological reliability and structured participant engagement strategies appear to be instrumental in implementing QR-based methods in observational research.

QR codes are most effective in capturing straightforward, quantitative aspects of user navigation, such as movement patterns, timestamps, and scan sequences, rather than complex, qualitative behaviors. While the *QRPath Insights* successfully recorded when and where participants engaged with checkpoints, it could not capture deeper contextual information, including participants' cognitive strategies, decision-making processes, and responses to environmental cues. These dimensions are central to understanding UX and wayfinding, but they were obtained only through human observation. Future research should explicitly integrate these complementary data sources to maximize the strengths of both approaches. One practical strategy would be to systematically map observational insights (e.g., points of confusion, hesitation, or noncompliance) onto the quantitative path data captured by QR codes. Such an analysis could reveal patterns that are not identifiable through either method alone, enhancing the explanatory power of findings and informing targeted interventions in spatial design or navigational tools.

Consequently, the applicability of QR codes is currently constrained in research contexts that require interpretive insights into UB and interaction. To address this limitation, we recognize that although the QR code approach shows promise for automating aspects of data collection, the efficiency gains observed in this study were highly context-dependent. QR codes did reduce the burden on human observers by automating the capture of timestamped path data and enabling the collection of survey responses remotely. However, this benefit was mitigated by challenges such as missed scans, session tracking errors, and variability in participant behavior. The time saved during data collection was partially offset by the need for manual post-processing and continued reliance on human observation. As such, while the results are encouraging, they do not yet constitute evidence of efficiency improvements. Future research should involve larger-scale implementations, stronger participant engagement strategies, and technical enhancements to better assess the reliability and scalability of this method.

Another limitation involves the visibility and placement of QR codes along predefined routes, which may have unintentionally influenced participant navigation behaviors. For some users, the QR codes functioned as implicit directional cues, subtly guiding them along specific paths and potentially confounding the evaluation of other navigation aids, such as the map. In contrast, participants who strayed from these routes often found no additional QR codes, resulting in unlogged segments of their journey and underrepresentation of natural wayfinding behavior. To mitigate this issue, future research should include a control group navigating without QR codes to isolate the influence of the technology and enable more accurate assessments of other informational or spatial supports.

Furthermore, future research could build on the findings and limitations of this study by implementing larger-scale deployments across diverse physical environments to test the generalizability of QR code-based observational methods. To reduce scan noncompliance and improve data completeness, future studies could experiment with less obtrusive QR code designs, enhanced placement strategies, and user prompts or incentives. Technical improvements to the METRIC system, such as more robust session tracking and real-time error detection, could address data accuracy challenges. Incorporating control groups and alternative navigational tasks could help isolate the impact of QR codes on behavior, allowing for more nuanced evaluations of spatial information systems.

With future enhancements, such as improved real-time tracking and behavioral annotation capabilities, METRIC could further reduce the need for human observers, improve data collection efficiency, minimize the risk of observer-related inconsistencies, and streamline the overall research process in physical information environments. In considering future improvements to automated data collection, Bluetooth beacons offer a promising alternative to QR codes, as they enable passive tracking without requiring user interaction. Beacons provide broader coverage and real-time tracking, but may suffer from reduced accuracy in complex architectural spaces due to signal interference [7]. In contrast, QR codes require active engagement but yield precise, intentional data points. Future research should compare these technologies in terms of accuracy, reliability, user-friendliness, and adaptability to clarify their respective strengths for hybrid observational methods.

6 Conclusion

This study explored a novel approach to observational research by incorporating QR codes as a means of modernizing traditional, labor-intensive data collection practices. By leveraging resource-efficient technologies, the method aimed to improve both data acquisition and participant engagement. Findings suggest that QR codes are a feasible tool for tracking user movement and gathering feedback. The METRIC *QRPath Insights* effectively captured usage patterns and navigational challenges, facilitating the evaluation of the NL's spatial information aid. QR codes demonstrated the potential for accelerating data collection and reducing dependency on human resources. However, several execution-related challenges, such as scan compliance, behavioral variability, and technical limitations, tempered the method's effectiveness. QR codes currently function best as a complementary tool rather than a standalone solution. Continued development of supporting technologies will be essential for realizing the full potential of QR codes in future observational research within physical information environments.

Acknowledgments

GENERATIVE AI USE

We employed OpenAI 4o for the following purpose(s): copy editing. We evaluated the output by reading and editing the text. The authors assume all responsibility for the content of this submission.

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