

User-Centered Design and Development of the Nuclear Safety Information Sharing Portal : A Case Study from Phase II of the Nuclear Safety Information Sharing Framework

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***Keywords :** nuclear safety information, user-centered design, UX strategy, information architecture, public portal

1. Introduction

1.1 Background of the Study

With the enforcement of the Act on Nuclear Safety Information Disclosure and Communication (Nuclear Safety Communication Act)¹, a comprehensive reorganization and advancement of the nuclear safety information sharing framework² became necessary, including revisions to the scope of disclosure, responsible entities, and sharing methods.

Accordingly, a phased project has been underway since 2024 to transform the Nuclear Safety Information Center (NSIC)³, previously operated under the Nuclear Safety Act, into a comprehensive nuclear safety information sharing system based on the Nuclear Safety Communication Act.

The Korea Institute of Nuclear Safety (KINS), designated by the Nuclear Safety and Security Commission (NSSC) as the specialized institution⁴ for nuclear safety information sharing, established a vision, strategic objectives, implementation tasks, and a phased roadmap for the Nuclear Safety Information Sharing Framework.

In line with this roadmap, an integrated management system for the registration and management of safety information from eight related institutions was developed in 2024.⁵ In 2025, as the second-phase project, the Nuclear Safety Information Sharing Portal (NSPortal, nsinfo.go.kr) was developed as a public platform. The third phase aims to establish an integrated online-offline nuclear safety information sharing framework enhanced with intelligent information services.

1.2 Scope and Methodology of the Study

This study examines the development case of the NSPortal (nsinfo.go.kr) as the second-phase project of the three-phase roadmap for advancing the online nuclear safety information disclosure system. In response to the institutional changes following the enforcement of the Nuclear Safety Communication Act—particularly the expansion of disclosure scope and the strengthened emphasis on public participation and communication—the project sought to move beyond a conventional information provision model toward the implementation of an expanded, user-centered information disclosure environment.

To this end, this study conducted a theoretical review of user experience (UX) in public websites and analyzed portal users and service usage patterns. Based on these analyses, customized UX elements were derived and subsequently reflected in the user interface (UI) design, and the implementation process is presented as a case study.

2. Theoretical Background

While UX has been defined in various ways, ISO 9241-210, which addresses human-centred design for interactive systems, defines UX as all perceptions and responses resulting from a user's interaction with a product, system, or service [1]. In other words, UX can be understood as a comprehensive concept encompassing the overall experience a user has throughout the interaction process. While UX represents an overarching concept that includes all aspects of user interaction—such as design, interface, and interaction—

¹ Enacted on June 8, 2021 and enforced on June 9, 2022. Article 3 of the Act stipulates that "This Act shall prevail over other statutes in regard to the disclosure of nuclear safety information."

² Under the Nuclear Safety Communication Act, nuclear safety information sharing is used as an umbrella concept that encompasses both online information disclosure and offline information sharing and communication activities.

³ This is an online platform (<http://nsic.nssc.go.kr>) established under Article 103-2 of the Nuclear Safety Act (Obligation to Disclose Information), which mandates the public disclosure of nuclear safety information, including reviews of construction and operating licenses for nuclear facilities and

nuclear safety inspections. The site has been built and operated KINS under entrustment from the NSSC.

⁴ The Specialized Institution for Nuclear Safety Information shall provide comprehensive support, including the management and preservation, processing and analysis of nuclear safety information; the provision and interpretation of such information to local residents; the establishment and operation of an integrated information system; and support for the establishment and operation of local Nuclear Safety Information Sharing Centers

⁵ The details of the project conducted in 2024 are documented in a paper presented at the Korean Nuclear Society 2025 Spring Meeting (*Development of the Nuclear Safety Information Disclosure Framework*).

UI generally refers to the visual and structural elements presented on digital device screens, including PCs, smartphones, and tablets [2]. Specifically, UI includes visual design components such as page layout, color schemes, typography, and buttons. In this sense, UI functions as a concrete means—through design and functionality—by which UX is realized.

Previous studies on public data portals similarly emphasize that UX is formed through the integration of multiple factors. Sari et al. pointed out that portal usefulness, user-friendliness, and information accessibility significantly influence UX [3]. These findings suggest that enhancing UX in public portals requires strengthening usability—by enabling effective information exploration aligned with user needs and expectations—and accessibility—by reducing barriers to information access through improved readability, technical support, and inclusive design. This implies that UX in public portal environments extends beyond aesthetic design elements and is closely related to functional and structural factors.

Accordingly, to improve user satisfaction and encourage sustained utilization of public portals, it is necessary to systematically understand the core components of UX. This study conceptualizes UX as an overarching framework and focuses on usability and accessibility as its primary subcomponents.

Usability refers to the degree to which a product or system enables users to achieve specified goals with effectiveness, efficiency, and satisfaction [4]. In the context of public portals, usability is closely associated with the ease of information search, intuitiveness of menu structures, and the accuracy of search functions. In the context of public portals, usability is closely associated with ease of information search, intuitiveness of menu structures, and accuracy of search functions.

Accessibility, on the other hand, refers to the degree to which all users can access information and services regardless of physical, cognitive, or technological constraints. The Korean Web Content Accessibility Guidelines define web accessibility as enabling persons with disabilities and older adults to access the web on an equal basis with others [5]. Accessibility encompasses not only technical compatibility but also various interface elements that enhance clarity and comprehensibility of information. In public web environments, accessibility serves as a key factor in ensuring equity and inclusiveness in information access.

Ultimately, UX in public portals can be strengthened when usability—enhancing efficiency and intuitiveness of information exploration—and accessibility—ensuring inclusive and barrier-free access—are integratively implemented.

Based on this framework, this study adopts usability and accessibility as the core analytical dimensions of UX and applies them to analyze actual usage patterns of the NSIC. The major UX elements derived from this analysis are subsequently reflected in the UI design of the

NSPortal, and the implementation process is presented empirically.

3. Development of User-Centered UX Design Strategies

3.1 Definition of User Groups

The primary users of the NSIC were classified into three groups based on the environmental and status analysis conducted in 2024, web log analysis of the NSIC, and survey results. The classification also considered the scope of stakeholders and key communication targets identified through public consultation and hearings.

Table I: User Groups of the NSIC

User Group	Definition	Examples
General Public	Individuals who do not have direct interests in nuclear facilities but possess general concerns regarding nuclear safety and seek related information as potential non-expert users.	<ul style="list-style-type: none"> - People verifying facts after encountering nuclear-related issues in the news - Parents searching for basic information on radiation for educational purposes - People interested in radiation safety levels
Local Residents Living in the Near Nuclear Facilities (Local Residents)	Individuals residing in areas surrounding nuclear power plants, research facilities, or radioactive waste management facilities, who have direct, everyday interests related to nuclear safety.	<ul style="list-style-type: none"> - A community representative seeking to review the results of regional safety inspections - Local residents searching for materials from briefing sessions held by nuclear operators
Industry-Academia-Research Cooperation (Professionals)	Professionals affiliated with nuclear-related industries, research institutions, universities, or regulatory bodies who utilize safety information for professional purposes, such as research, policy analysis, or project implementation.	<ul style="list-style-type: none"> - A university researcher conducting studies on radiation safety - An industry official reviewing regulatory Standards - A policy researcher preparing a governmental report

The general public constitute a group that explores information based on non-specialized interests. As they

have relatively low direct stakes in nuclear safety issues, their routine frequency of use is not high. However, their information-seeking activity tends to increase significantly during national issues or major incidents. Compared to technical reports, they show greater interest in information closely related to everyday life, such as environmental radiation levels and marine radiation measurements. Given their comparatively limited expertise, they require information to be presented in the form of visualization, summaries, and explanatory content rather than direct provision of original technical documents.

Local residents primarily seek safety information directly related to their area of residence. Their information exploration is typically centered on nuclear facilities located within their region, and they demonstrate a higher level of sustained interest than general citizens. Although they also tend to have limited technical expertise and therefore benefit from visualized information, their strong livelihood-based interests may make them particularly sensitive to the credibility of information. Accordingly, providing original source documents alongside processed and summarized content is considered necessary to ensure trustworthiness.

Professionals are characterized by their orientation toward in-depth data utilization for specialized purposes. Compared to other groups, their information demands are more specific and clearly defined, and they tend to prefer original documents and raw data over processed summaries. In addition, there is demand for customized management functions—such as saving and organizing selected information—to support professional use in their work.

Table II: Information Use Characteristics by User Group

Category	General Public	Local Residents	Professionals
Purpose of Use	Anxiety mitigation, understanding current issues, acquiring general knowledge	Confirming regional safety status and inspection results	Conducting research tasks, policy and technical analysis
Information-Seeking Behavior	Issue-centered exploration; focus on information closely related to daily life	Exploration based on specific regions and facilities	Exploration based on specific professional fields
Preferred Information Types	- Daily life-related safety information	- Regional environmental radiation levels - Facility-specific information	- Original data - Policy and technical reports

⁶ Under the Nuclear Safety Communication Act, a total of eight institutions are designated as subject to nuclear safety

Category	General Public	Local Residents	Professionals
	- Current issue-related information	- documents from public hearings and local council meetings	
Information Format Preference	Visualization-oriented content (such as infographics, graphs, and cards)	Processed content combined with original documents	Original source documents and data

Table II presents a comparative analysis of the major user groups of the Nuclear Safety Information Sharing Portal in terms of information-seeking behavior, preferred information types, and preferred information formats. The analysis confirms distinct usage characteristics across user groups, highlighting the necessity of developing UX design strategies that reflect the specific needs and attributes of each group.

3.2 User Behavior Analysis

3.2.1 NSIC Web Log Analysis

First, quantitative analysis was conducted using NSIC web log data from 2022 to 2024 to examine key indicators related to user activity.

In terms of visitor trends, the number of annual visitors was 338,136 in 2022, 447,485 in 2023, and 483,249 in 2024, with a three-year average of 422,957 visitors. A substantial increase was observed in 2023 compared to the previous year, coinciding with the Fukushima treated water discharge issue. The upward trend was maintained thereafter, suggesting sustained public interest in nuclear safety information.

Analysis of major menu usage statistics in 2024 showed that the “Regional Information” section, which provides nuclear safety information based on the locations of nuclear power plants, recorded the highest usage rate at 21.9%. This was followed by the “Reactor” menu (18.2%), which offers safety information related to nuclear power plants and research reactors, and the menu providing safety information by nuclear safety information-related institution⁶ (17.5%).

These findings indicate that users tend to prioritize safety information directly related to their region or specific facilities. In particular, the high access frequency to region-based and facility-level information suggests the need to structure content around frequently searched topics—such as facilities and regions—and to design an intuitive UI that enables direct and efficient access to such information.

Meanwhile, institution-based exploration also accounts for a meaningful proportion of user activity. However, the current NSIC lacks an integrated search function across related institutions, and safety information from each institution is accessible only through a separate compilation page. This structural limitation fragments the user navigation flow and may have influenced the distribution of menu usage.

information disclosure: NSSC, KINS, KINAC, KOFONS, KHNP, KORAD, KNF, and KAERI.

3.2.2 Analysis of NSIC User Satisfaction Survey Results

Next, the results of the 2024 NSIC online user satisfaction survey were analyzed. The survey was conducted from November 1 to 14, 2024, among members of the general public who visited the NSIC, and the questionnaire was administered online. A total of 2,803 respondents participated. Because the survey included both structured and open-ended items, both quantitative and qualitative analyses were conducted.

First, based on respondents' demographic information, user characteristics were examined in terms of age group, occupation, access device, and types of information accessed.

With regard to age distribution, respondents in their 30s accounted for the largest proportion at 44.2%, followed by those in their 40s (28.0%) and 20s (17.1%). This indicates that middle-aged adults (30–49 years) constitute the primary user group of the NSIC.

In terms of occupation, office workers represented the highest proportion at 63.8%, followed by self-employed individuals (9.6%), university and graduate students (8.3%), homemakers (7.5%), and professionals in nuclear and radiation-related fields (5.2%). This distribution suggests that non-specialist users, particularly general office workers, form the majority of NSIC users rather than domain experts.

Analysis of access devices showed that smartphones were used most frequently (63.3%), followed by PCs (22.5%) and tablets (13.9%), clearly demonstrating a mobile-centered usage pattern. This finding implies that mobile optimization should be a key consideration in future UI design.

Regarding the types of information accessed, "Nuclear Safety Information" accounted for 31.1%, followed by "Open Information (videos and publications)" at 26.2%, "Marine Environmental Monitoring Information" at 21.0%, and "Accidents, Malfunctions, and Status Reports" at 18.9%. Although the "Nuclear Safety Information" menu—primarily providing original source documents—recorded the highest usage rate, the other top-ranked menus consist largely of visualized or summarized content closely related to everyday safety concerns. This suggests that users demonstrate strong interest not only in original technical materials but also in information that has been reorganized into more accessible and comprehensible formats.

Finally, qualitative analysis was conducted on responses to the open-ended question regarding additional requirements and suggestions for improvement. By categorizing responses into similar thematic groups, major UX design directions reflecting user needs were derived, as summarized in Table III

Table III: UX Elements Proposed from Survey Responses

Survey Responses	Proposed UX Elements
<ul style="list-style-type: none"> - Marine radiation levels in Korea - Radiological safety status of seafood - Radiation levels in areas near nuclear power plants - Emergency response guidelines for radiation exposure 	Provision of safety information relevant to current issues and daily life

Survey Responses	Proposed UX Elements
<ul style="list-style-type: none"> - Requests for enhanced visualization of numerical data and infographics - Demand for video- and image-based content 	Enhancement of visual content for intuitive and user-friendly information delivery
<ul style="list-style-type: none"> - Transparent disclosure of information on nuclear safety trends and policy plans - Requests for more specific information on facility safety 	Expansion of original source document disclosure to strengthen transparency

3.2.3 Key Findings and Implications

A summary of the NSIC web log analysis and user satisfaction survey results reveals a clear tendency among users to explore information centered on specific topics, particularly regions and facilities. In addition, the findings indicate a strong demand for intuitive and concise information structures within a predominantly mobile access environment.

The analysis also identified structural limitations in the current system, where safety information is provided separately by related institutions and an integrated search function is not supported. This fragmented configuration disrupts the continuity of user navigation and highlights the need for system improvement.

These results suggest that UX design strategies should prioritize the enhancement of topic-centered navigation structures alongside the implementation of integrated search functions. Furthermore, strengthening accessibility and visualization—taking into account users' access environments and levels of understanding—should be established as key directions for UX design.

3.3 Development of UX Design Strategies

As discussed in the theoretical background, usability refers to the extent to which users can achieve specific goals effectively and efficiently, whereas accessibility denotes the degree to which diverse users can access information without physical or cognitive barriers. This study adopted usability and accessibility as the analytical framework and derived UX design directions based on the analysis of NSIC user groups and usage behavior.

The analysis of user types confirmed that differences exist across groups in terms of information-seeking behavior, preferred information types, and preferred information formats. These findings underscore the necessity of developing UX design strategies that reflect the distinct characteristics and needs of each user group.

Meanwhile, the web log analysis and user satisfaction survey results indicated that users tend to explore information centered on specific topics, such as regions and facilities, and demand intuitive and concise information structures within a predominantly mobile environment. In addition, the absence of an integrated search function was identified as a factor that reduces search efficiency.

Accordingly, the core UX design directions were established as follows: restructuring the search system, improving topic-centered navigation, and strengthening accessibility and visualization by taking into account users' access environments and levels of understanding.

Table IV: Developed UX Design Directions

Analysis Category	Key Findings	Proposed UX Design Directions
User Group Analysis	Differences in information-seeking behavior and user needs across groups	Improve information architecture by reflecting the characteristics of each user group
NSIC Web Log Analysis	Topic-centered exploration patterns; absence of integrated search	Reorganize the information structure around core topics (facilities and regions) and enhance integrated search functionality
User Satisfaction Survey Results	High mobile usage rate; demand for easy-to-understand information	Strengthen accessibility and visualization to support mobile environments and diverse levels of understanding

The following chapter presents how the developed UX design strategies were concretely reflected in the actual UI implementation.

4. UI Implementation of UX Design Strategies

4.1 Reconfiguration of the Menu Structure Based on User Groups

The analysis of user groups revealed differences among the general public, local residents, professionals in terms of information-seeking purposes and preferred information types. Accordingly, the menu structure was reorganized based on usage purposes rather than institutional categories.

For the general public, whose primary objective is to verify the current safety status, key safety indicators were prominently positioned on the main screen. This configuration simplified the access path to information closely related to everyday life and enabled more immediate confirmation of essential safety data.



Fig. 1. Main Page Displaying Real-Time Safety Information

For local residents, region-based navigation was implemented by creating dedicated pages for areas in which nuclear facilities are located, including Gijang, Gyeongju, Yeonggwang-Gochang, Uljin, Ulju, and Daejeon. Each regional page integrates key safety indicators with original source documents, thereby enhancing both the efficiency of information access and overall readability.



Fig. 2. Region-Specific Page Interface

For professional users, a login-based personalized service was introduced to enable the bookmarking of materials in their areas of interest and the utilization of information for specific work-related purposes.



Fig. 3. Personalized Information Page for Registered Members

Through this approach, a differentiated information access system reflecting the characteristics of each user group was implemented.

4.2. Redesign of the IA and Navigation Structure

According to the findings presented in Chapter 3, the existing information structure was fragmented by related institutions, which disrupted the continuity of user navigation. In addition, users demonstrated a clear

tendency to explore information centered on specific topics, such as regions and facilities. To address these issues, the information architecture (IA) was reorganized to enable both integrated search and topic-centered navigation, allowing users to select their preferred exploration method based on their objectives.

First, nuclear safety information that had previously been separated by institution was consolidated into a unified system and linked to an integrated search framework. This improvement allows users to comprehensively search all safety-related information through a single search interface.

Considering the characteristics of nuclear safety information, multiple advanced search filters were designed, enabling detailed configuration by title/full text, time period, producing institution, target facility, location, related materials, and classification system. Through this design, the study sought to enhance search efficiency and ensure consistency in information access.

안전정보 통합검색

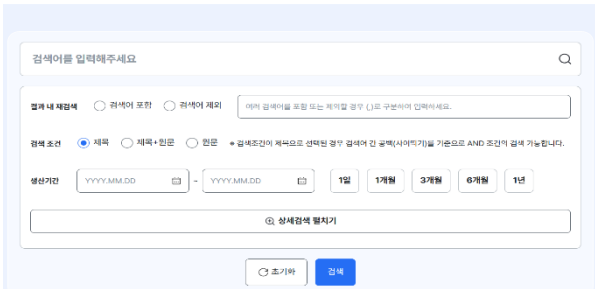


Fig. 4. Integrated Search Interface

In addition, a new “Topic-Based Information” menu was introduced to reorganize content around key themes such as facilities, materials, and nuclear regulatory procedures. In this process, visualization elements—including a map-based interface—were incorporated to enable users to explore information intuitively according to their areas of interest.

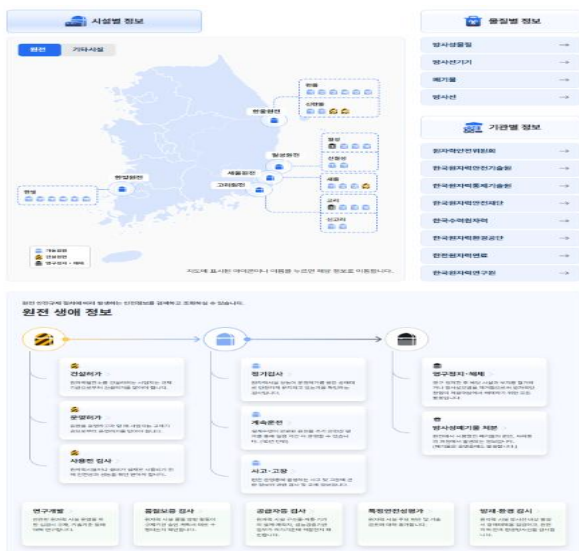


Fig. 5. Topic-Based Information Page

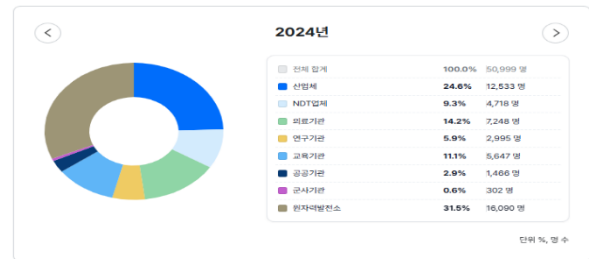
4.3 Enhancement of Accessibility and Visualization

The usage behavior analysis presented in Chapter 3 indicated a high proportion of mobile-based access and a strong demand for information presented in an easily understandable manner. Accordingly, the UI was designed to strengthen both information accessibility and visual communicability.

First, a responsive web structure was adopted to accommodate mobile usage environments, thereby ensuring readability and navigational convenience across various screen sizes.

In addition, numerically oriented information throughout the portal was restructured into infographic formats utilizing graphs, icons, and color schemes to facilitate intuitive comprehension. High-contrast color combinations were applied to enhance accessibility for vulnerable user groups, including individuals with low vision. Furthermore, barrier-free elements were incorporated—such as the provision of subtitles for video content—to reinforce inclusivity in information access.

연도별 방사선 작업 종사자수 통계



업종별 방사선 작업 종사자수 추이

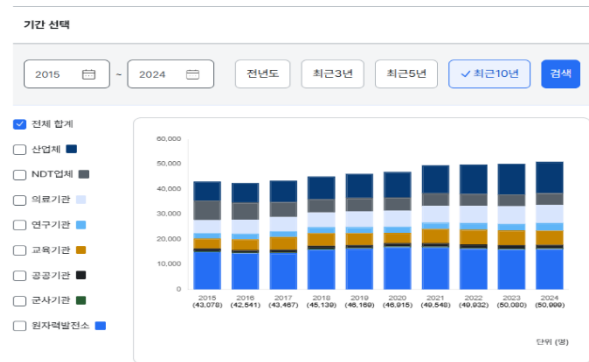


Fig. 6. Visualization of Radiation Safety Statistics

5. Conclusions

This study examined the UX design and UI implementation of the NSPortal in response to changes in the information disclosure environment following the enforcement of the Nuclear Safety Communication Act. Moving beyond the previously fragmented information disclosure structure, the study redesigned the information architecture based on actual user behavior and needs, thereby establishing a user-centered information system.

By defining NSIC user groups and integrating findings from web log analysis and user satisfaction surveys, the study identified distinct differences among user types—the general public, local residents, and professionals—in terms of information-seeking purposes and preferred content types. Users generally demonstrated a tendency to explore information centered on specific topics, such as regions and facilities. In addition, there was a strong demand for intuitive and easily understandable information presentation, along with a high rate of mobile-based access, highlighting the necessity of mobile compatibility.

Based on these findings, three core UX design strategies were proposed and implemented in the UI:

- (1) Reconfiguration of the menu structure reflecting user groups;
- (2) improvement of the navigation structure through the implementation of integrated search and topic-centered information architecture; and
- (3) enhancement of accessibility and communicability through responsive web design and infographic-based visualization.

Through these strategies, the portal improved the efficiency and intuitiveness of information exploration and established a foundation that enables diverse users to access nuclear safety information without barriers.

This implementation is significant not merely as a functional upgrade but as an empirical application of UX design strategies derived from systematic user analysis and directly reflected in UI development.

Nevertheless, the study has limitations in that the analysis was conducted based on relatively limited user behavior data. In particular, long-term usage data and continuous user feedback following the full-scale operation of the portal were not sufficiently incorporated. Future research should accumulate and analyze longitudinal usage data and integrate user feedback into portal operations to further advance a sustainable, user-centered management system.

REFERENCES

- [1] ISO 9241-210, Ergonomics of Human-System Interaction – Part 210: Human-Centred Design for Interactive Systems, International Organization for Standardization, 2019.
- [2] Ministry of the Interior and Safety, A Study on Standardization of Public Web and App UI/UX Based on User Data Analysis, Ministry of the Interior and Safety, pp. 18-19, 2023.
- [3] Dwi Puspita Sari et al., Enhancing user experience: An accessibility and usability study of an open government data portal, Dg.o 2025 - 26th Annual International Conference on Digital Government Research, 2025.
- [4] ISO 9241-11, Ergonomics of Human-System Interaction – Part 11: Usability: Definitions and Concepts, International Organization for Standardization, 2018.
- [5] KS X OT0003, Korean Web Content Accessibility Guidelines 2.2, Korea Communications Standards Commission, p.2, 2022.