User Testing Insights of Application and Dashboard Interfaces for a Real-Time Campus Space Monitoring Solution

Mafalda Morgado[1](✉), Hande Ayanoglu[1,2], and Edirlei Soares de Lima[3]

[1] UNIDCOM/IADE, Unidade de Investigação em Design e Comunicação, Av. D. Carlos I, 4, 1200-649 Lisbon, Portugal
mafalda.morgado@tecnico.ulisboa.pt, hande.ayanoglu@universidadeeuropeia.pt

[2] IADE, Faculdade de Design, Tecnologia e Comunicação, Universidade Europeia, Av. D. Carlos I, 4, 1200-649 Lisbon, Portugal

[3] Academy for AI, Games and Media, Breda University of Applied Sciences, Breda, The Netherlands
soaresdelima.e@buas.nl

Abstract. This study explores user preferences and the user experience of the interfaces of two proposed digital solutions, a dashboard and a smartphone app, in the context of a system for monitoring campus spaces at IADE - Universidade Europeia in Lisbon, Portugal, to collect real-time data on occupancy and indoor environmental quality factors, and aiming to enhance campus experience. Ten IADE students performed tasks through high-fidelity, interactive wireframes of the app, in order to pinpoint any usability challenges. Concerning the initial wireframes of the dashboard UI, user preferences and expectations were explored in interviews with ten adults with IT, system administration, or office management backgrounds. Generally positive results revealed that users were satisfied with the visual design and ease of use of the app; however, further improvements must be made to ensure element hierarchy in properly conveyed, and the navigation fits users' expectations. Feedback from dashboard users identified a need to refine the information architecture. Participants highlighted the need for concise and easily perceivable information, in a main screen which offers a summary and AI-powered insights, while more comprehensive data is accessible through secondary pages. Additionally, page layouts and data representation should accommodate different user roles and their different needs. While the findings of this study may contribute to the user-centered design process of other similar initiatives, further research should include a broader and larger sample to ensure the findings are generalizable to other educational institutions.

Keywords: Wireframe Testing · User Experience · Student Experience · Smart Campus · Internet of Things

M. Kurosu and A. Hashizume (Eds.): HCII 2025, LNCS 15766, pp. 84–102, 2025.
https://doi.org/10.1007/978-3-031-93835-1_6

1 Introduction

The integration of Internet of Things (IoT) technologies facilitates intelligent environments where, through sensors and unique identification systems, everyday objects can integrate a data-driven ecosystem, supporting campus facilities monitoring (Abuarqoub et al., 2017).

The employment of IoT can streamline operational processes, such as through the automation of paper-based tasks and services, thus facilitating existing workflows (allowing, consequently, for a quicker response to emerging needs), and minimizing the likelihood of human oversight. Additionally, the existence of an integrated system fosters data-driven decision making, facilitating the optimization of resource allocation and the improvement of service quality (Madyatmadja et al., 2021).

Smart campuses leverage such technologies to create an intelligent, efficient, and user-friendly environment, integrating information services which enhance operational efficiency, optimization resource management, sustainability and user experience (Arunkumar et al., 2024; Muhamad et al., 2017). IoT technologies can inform strategic campus management, particularly for universities dealing with fluctuating student numbers, limited resources, and aging infrastructure (Valks et al., 2021).

These systems can include the strategic use of sensors (such as motion, or changes in the indoor environment) and contactless technologies (such as Bluetooth or NFC) for user convenience, the use of web services for unified information access, a point of access for students and lecturers such as a dashboard, among others (Muhamad et al., 2017).

A case study at Umeå University demonstrated how data analysis insights from motion sensors and booking systems on their campus could be applied to optimize space management decisions (such as shutting down redundant spaces), reducing resource consumption in their facilities. These findings highlight the potential of IoT to support informed space management and resource allocation decisions based on data-driven insights (Azizi et al., 2020).

The three applications of IoT technologies on campus most frequently found in literature correspond to location-based services, infrastructure optimization services, and user flow monitoring. The same solution may consist of more than one of these applications, addressing both user comfort and user support, and resource optimization and operational priorities (Valks et al., 2021); through user tracking, the solution can support users in navigating the facilities and locating specific resources, while providing information on the patterns of usage levels and occupant circulation in the facilities. Additionally, automated approaches that respond to occupant presence or environmental conditions improve resource usage efficiency and occupant comfort.

There are challenges associated with such systems, such as labor-intensive manual configurations of IoT devices, the heterogeneity of IoT devices and their data, the management and processing of large amounts of generated data (particularly when it is performed in real time, resulting in higher requirements for communication and processing units), and the efficiency required in power supply these devices (Abuarqoub et al., 2017).

Thus, several factors should be considered when adopting IoT on campuses. The two most critical factors include (1) ensuring the interoperability of the multiple, and heterogenous, IoT devices to facilitate seamless communication; and (2) encouraging user engagement and applying user-centric practices in the development to ensure user acceptance (from students, faculty and staff). Remaining factors to consider include the robustness of the existing infrastructure to support the new solution, the scalability of the solution, data privacy and secure data exchange within the system, cost evaluation, sustainable practices to minimize environmental impact, among others (Arunkumar et al., 2024).

The responsive environment and dynamic adjustment of campus infrastructure settings can be particularly relevant considering the impact on Indoor Environmental Quality (IEQ) factors.

The integration of IoT technology can be used to improve indoor air quality, for instance, to improve ventilation and heating by dynamically adjusting the HVAC system in accordance with real-time collected data on temperature, humidity, CO_2 levels, and occupancy rates. Data-driven, responsive adjustments not only allow for improved energy efficiency—considering HVAC systems are one of the most energy-consuming components in buildings—but also dynamically improve the indoor air quality, which impacts learning performance (Rinaldi et al., 2018).

The sixteen IEQ factors which can be categorised according to thermal comfort, lighting, acoustics, spatial comfort, and aesthetics, are directly linked to work productivity in academic settings and the well-being of occupants; particularly, lighting, noise, air quality and temperature regulation were considered the most critical environmental aspects by students and staff (Liu et al., 2023).

While it is important to consider and address challenges such as infrastructure constraints, interoperability, security vulnerabilities, data privacy concerns, and scalability limitations (Arunkumar et al., 2024), the applications of IoT in educational setting presents new opportunities to optimise learning and working conditions, occupant experience, space utilization and energy efficiency (Gilman et al., 2020), through occupancy detection and tracking, dynamic improvement of IEQ, automatization of maintenance, and improvements in resource management (and, consequently, in sustainability and cost reduction) (Abuarqoub et al., 2017). Additionally, it is crucial to ensure user acceptance and engagement through a user-centric approach in the interface design, by engaging the stakeholders in an iterative development process (Arunkumar et al., 2024).

1.1 Contextualization

The real-time data collection on characteristics of campus spaces can be useful for students, by facilitating the search process for space that meets their needs; the project developed by (Hicks et al., 2021) addresses the identified difficulty in finding an optimal location to study on campus, by utilizing a microcontroller, and a sensor to measure temperature, humidity, air quality and pressure data, as well as a library to collect Wi-Fi speed, and displaying the collected data on a web application.

In an analogous initiative to improve student, faculty and staff experience at the university of IADE – Universidade Europeia, in Lisbon, Portugal, a solution was proposed for the campus, encompassing a network of sensors installed across campus spaces which could collect data on occupancy and IEQ factors, displaying said data in real-time through a smartphone app. Furthermore, a dashboard would also be created for operational support and maintenance, allowing users to view current and past data across campus, as well as any issues and warnings regarding the network of sensors. Additional to the improvement of the learning and working experience on campus, such solution could contribute to the improvement the sustainability and efficacy of resource management of the facilities.

This study concerns simultaneously the later stage of the app interface design, particularly, user testing and feedback on interactive wireframes through task performing, as well as the first stage of the staff dashboard interface design, concerning mostly user feedback on needs, expectations and information architecture with the aid of initial sketches. In prior steps in development, particularly regarding the app, focus group sessions with students were conducted (Morgado et al., 2025) to analyze their current experience (including motivations, habits, and pain points) and their expectations and preferences regarding the digital product (impact and attributed value, relevant data to collect and display, data visualization, among others).

Following this initial session, we began an iterative design process (see Fig. 1 through Fig. 3), gradually defining the UI of the app, including architecture, navigation, and information visualization, conducting multiple informal testing sessions with students on campus at each stage.

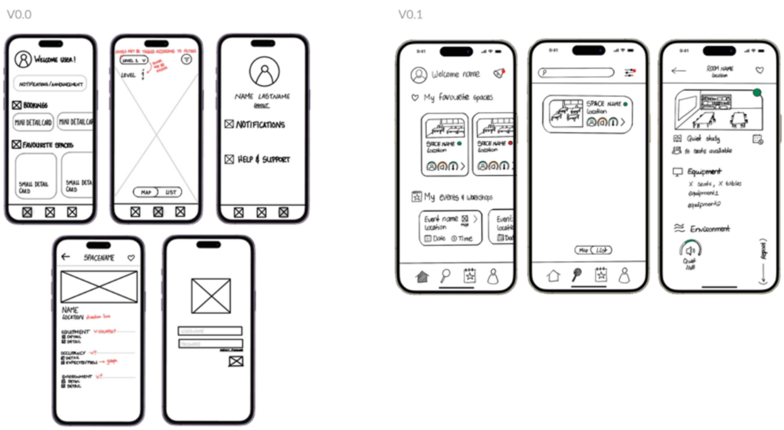

Fig. 1. Initial drawings and sketches.

The wireframes of the latest iteration in the UI design, which were applied in the user testing sessions of this study, are depicted in Fig. 4. While the home screen allows users to quickly add campus spaces to their favorite spaces (through the + button), the list of all campus rooms and common areas is accessible through the bottom menu; users are able to filter the listing, and search for a particular room. Each campus space, when selected, presents relevant data (defined in the early stage focus groups), such as availability and schedule, occupancy, type, equipment, and real-time data on the space's IEQ factors. These characteristics are conveyed primarily through icons, colors and qualitative information, as these were the preferred types of data representation by

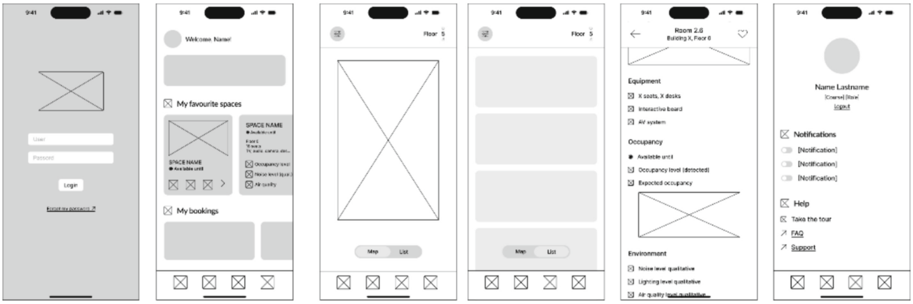

Fig. 2. Initial low-fi wireframes, of mainly containers.

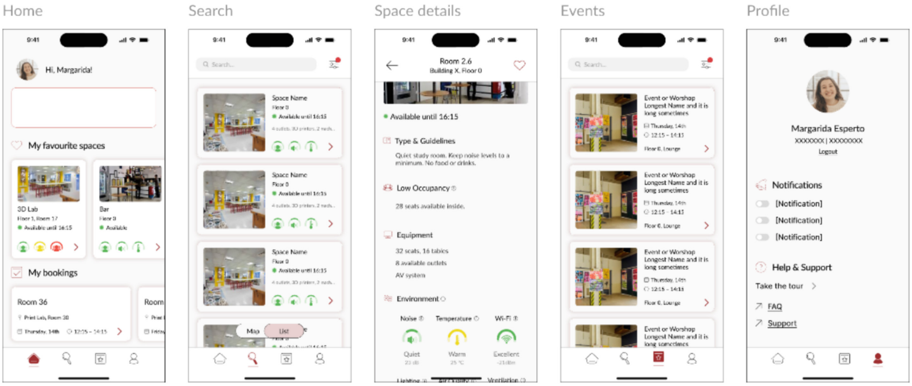

Fig. 3. Previous stage wireframes, without navigation or interactions.

IADE students. Users are also able to report inconsistencies in the data, issues with the sensors or the facilities, and other feedback. To address a previously identified need, the app also allows students to view, and be notified of, events and workshops (currently active, or planned) on campus. Through the home screen, they are able to sign up for an available workshop; additionally, the listing of all events and workshops, with is searchable and filterable, is accessed through the bottom menu. Finally, users can access their profile page to change notification settings, retake the onboarding tour or request support.

While the dashboard is still at a very early stage (see Fig. 5), user insights collected regarding the app will be applied in the final UI design iteration of the app, before proceeding with the technical development.

Figure 5 showcases the main screens involved in a simple flow of accessing the historical data of a room: (1) the user would login (top-left) with their credentials. At this early stage, profiles and roles were not yet considered; (2) the user reaches the home dashboard (top-right). This screen would allow the user to perform the following central tasks: navigate the building, view real-time data collection (a sensor status) of all spaces, view warnings for the entire building, and access historical data for all spaces in the building. The view of the building's status and data collection would be shifted

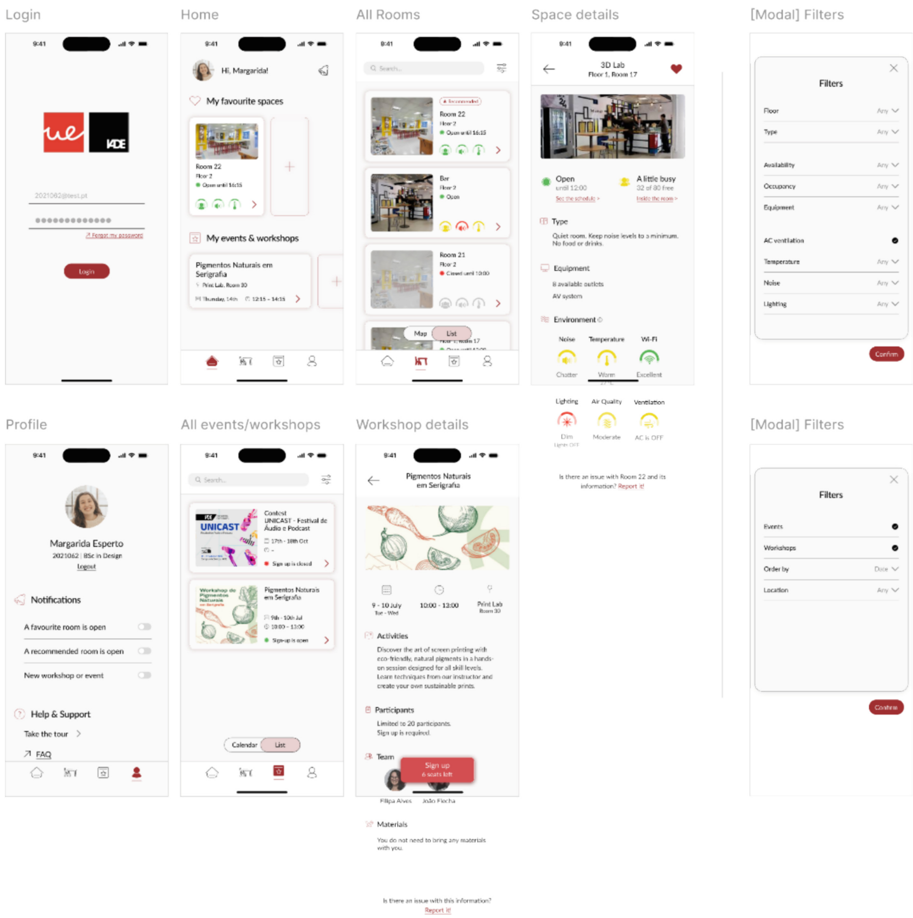

Fig. 4. Wireframes applied in this study.

between full map view, or "Schema View" (drag-to-navigate, and campus spaces and their information appear overlaid), a "List view" (room cards organized according to preferences and filters), and a "Split view", which is currently visible in the Fig. 5; (3) the user selects a room card and enters a detailed view of that space. Here, the data collection, errors and warnings, and sensor information data pertain only to the selected room. Similar to the previous screen, it would be possible to switch the view of the room, from "Schema" to "Grid" to display solely the cards of the stations, and "Sensor view" to see a listing of the sensors, detached from their units; and (4) the user selects the option "view historical data", to reach the bottom-left screen. The goal of this screen would be to allow users to view selectable data in a selectable format, filter, export data and identify trends.

These rough wireframes were applied in this study to promote concrete feedback and tangible changes, while defining expectations on tasks, content and data representation.

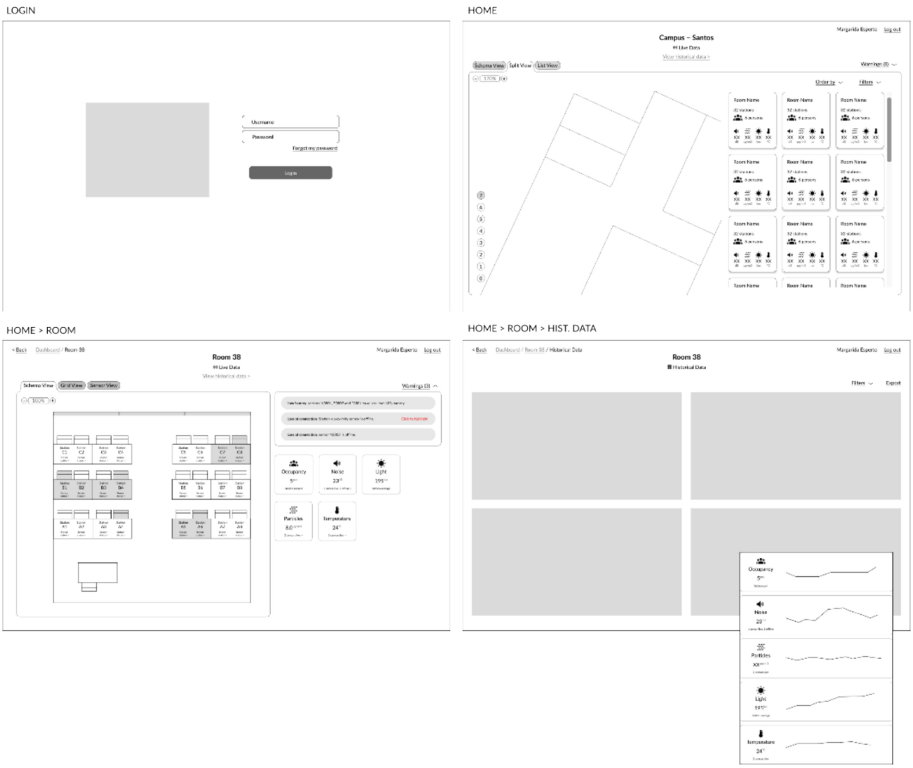

Fig. 5. Initial rough wireframes of the Dashboard, created for the first stage of user testing.

While the explored digital solution pertains to the campus and students of IADE-UE, the collected user insights on/and interface designs provided may be useful for other educational institutions aiming to develop similar initiatives, taking into account that further research must be performed to tailor the solution to the particular needs and requirements of its facilities and students.

In terms of ethical and privacy considerations, it is important to note that the proposed and idealised solution does not rely on tracking the users of the app; their locations are not collected nor stored. Additionally, the collected data on IEQ factors, space infrastructure status and occupancy levels do not require image or audio capture, thus, videos or pictures of the spaces and occupants are not taken nor stored. Noise-level detection can be performed through sensors that measure the volume (in decibel) and perform basic audio processing features in real-time, thus discarding raw audio and outputting/communicating solely numeric values.

2 Methodology

2.1 Dashboard

Design of the Study. This stage of the user testing study followed a quantitative approach, to assess the core tasks and priorities, the navigation and flow (consequently, information architecture), real-time and historical data vis, and overall feedback and expectations on content, through short semi-structured individual interviews.

Participants. This study was conducted with ten participants, of which 6 were male and 4 were female, with their ages ranging between 31 and 57 years old ($\mu \approx 41.2$; $\sigma \approx 7.67$). All participants worked at the time in IT support, system administration or office administration/management.

Procedure. The interviews were conducted individually, in-person, in the participant's professional or home offices, with an approximate duration of 9 min. Each session followed the three stages below.

1. *Introduction to the project and study.* Demographic information was collected, and the participants were introduced to the context of the study, and the goal of the digital product in evaluation.
2. *Expectations of tasks and features.* The second stage focused on initial expectations of the participants, considering the goal of the product and the information collected; and the following topics were explored prior to discussing the existing sketches:
   a. Primary tasks to accomplish at different times/frequencies
   b. Notifications and alerts
   c. Information export
   d. Additional feedback or suggestions
3. *Data and visuals.* At this stage, the wireframes (see Fig. 5) are presented to the participants as they are encouraged to analyze them and Think Aloud; any questions or doubts were noted and clarified. With the aid of wireframes, the following topics were discussed:
   a. Expected information on main screen
   b. Feedback on architecture
   c. Data representation, real-time and historical
   d. Additional feedback or suggestions

Due to the loosely structured nature of the sessions, the discussion was not restricted to the above-mentioned topics, and not all these questions were covered with the same depth across participants.

2.2 Application

Design of the Study. This stage of the user testing study followed a mixed-data approach, in which the moderated sessions collected quantitative data through task execution (data concerns the metrics of average duration, success rate, type of success path, and miss click rat), and qualitative data through the Think Aloud method and final remarks.

Participants. The study was conducted with ten participants, of which 5 were male and 5 were female, ages ranging between 19 and 25 years old ($\mu \approx 20.9$; $\sigma \approx 2.02$). All participants were students enrolled on bachelor's or master's degree at IADE-UE, in the areas of design, marketing, and communication.

Procedure. The moderated sessions were conducted individually, and took place in common areas of IADE campus, lasting between four to six minutes, in which the participants used the researcher's laptop running the simulated prototype to perform the tasks. Each session followed the three stages below:

1. *Introduction to the project and study*. The first stage of each session consisted in introducing and contextualizing the study, explaining the goal of the digital product, and collecting basic demographic information.
2. *Task performing*. After launching the prototype, users would perform five elemental tasks to explore the different functionalities and flows of the app. Users were not allowed free exploration prior to the tasks.
   a. Task 1 – Details of Room 22: in this task, users were required to verify information on the number of people and the noise level in room 22. The predicted flow of this task is showcased in Fig. 6, in which users would login with the given credentials, use the bottom menu to navigate to the list of rooms, select the correct room, and verify the required information (clicking the schedule item, and/or scrolling the page to find IEQ information).
   b. Task 2 – Favorite Room 22: users were asked to add room 22 to their favorites. The possible flows are showcased in Fig. 7, in which users would either use the "+" button on the home page, and select the room, or perform a similar path as in T1, favoriting the space in the room details page.
   c. Task 3 – Un-Favorite the 3D Lab: users were asked to remove the 3D Lab from their favorites. The possible flows are showcased in Fig. 8 and are analogous to T2.
   d. Task 4 – Sign up for an event: the two possible paths to successfully signing up for a currently available workshop or event are showcased in Fig. 9.
   e. Task 5 – Turn on a notification: users were required to turn on the notifications for when the event that a favorite room is open occurs. The path to success is depicted in Fig. 10.
3. *Final remarks*. Though, throughout the session, the Thinking Aloud method allowed the researcher to understand specific challenges or blocks of the participant, as well as take note of immediate feedback, in this final stage the participant was asked to share their thoughts on the usability of the app. Particularly, to comment on challenges, on the ease or difficulty of tasks, other preferred paths, visual preferences, among others. This stage is particularly relevant when participants did not complete a task, became blocked, or took longer than expected to complete it.

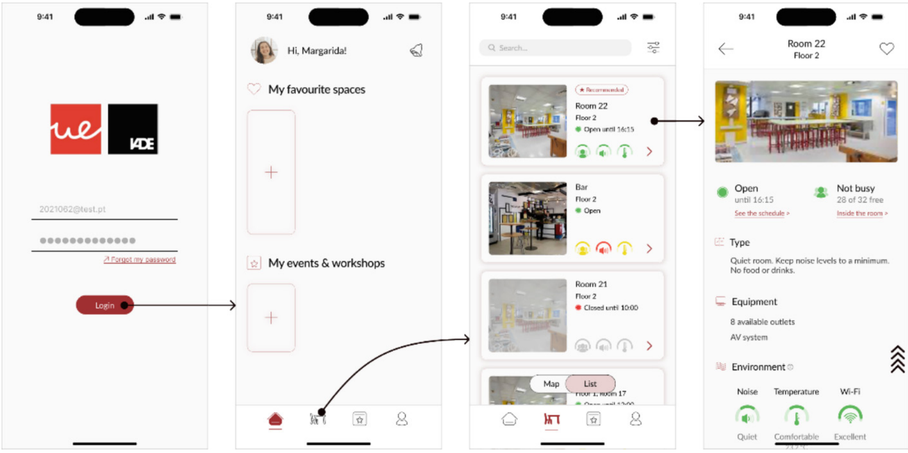

Fig. 6. T1: Path to success.

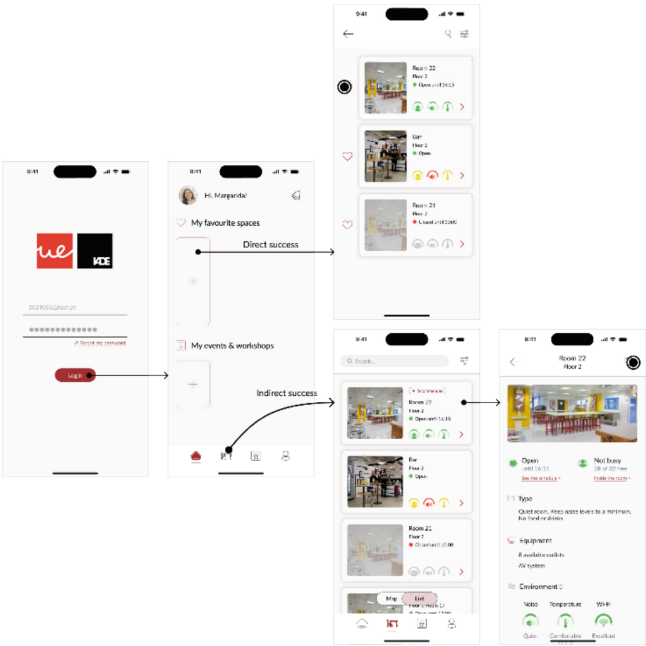

Fig. 7. T2: Paths to success.

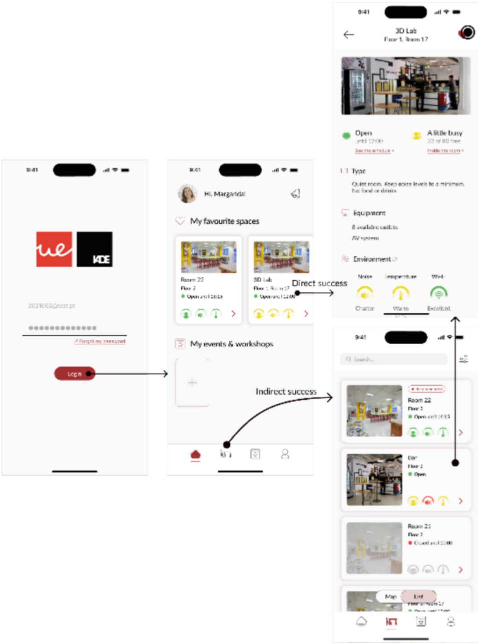

Fig. 8. T3: Paths to success.

3 Results

3.1 Dashboard

Expectation of tasks and features. In the context of a dashboard app, through which it is possible to access the system of data collection and the collected data in an educational institution, majority to all participants (from the perspective of their occupations) reported the digital product should generally allow them to (1) verify the state of a space, that is, whether a room is at capacity or the quality of its conditions. Two participants reported this should include the possibility to trigger a suggestion to the occupants of alternative spaces nearby; (2) verify the health and status of the system, including the network and all of the sensors; (3) verify the status of the building infrastructure, which systems were triggered, and when, and are currently operational (such as whether the HVAC system is running, with what settings, and whether the setting are fixed or responsive); (4) observe the usage of the space and the evolution of quality metrics (like IEQ factors) over time; and (5) access trend analysis and prediction, such as a forecast of occupancy or space conditions, possibly supported by an AI tool.

Even when suggesting the same features/tasks, the occupations of the participants influenced their granularity. While all participants mentioned the importance of being able to verify (and being notified) about the health of the sensors, participants of IT background referred that they should be able to view and know whether the sensors are sending data that “makes sense”, to view any error in detail if needed (rather than a simple warning), and to view or generate through the dashboard both a log of recent anomalies

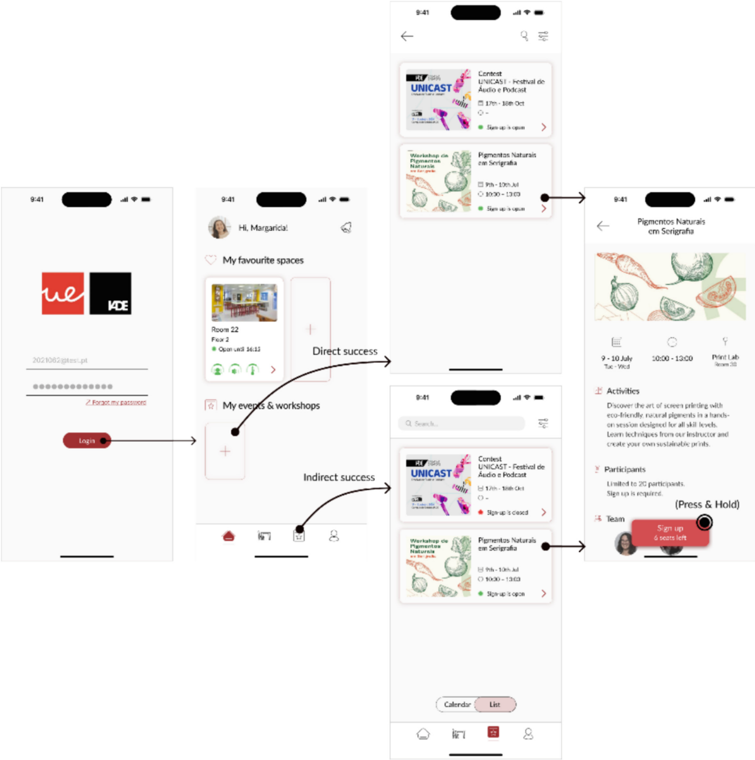

Fig. 9. T4: Paths to success.

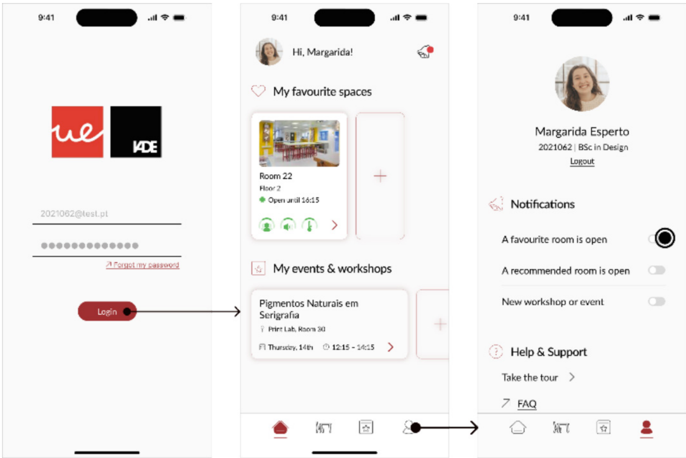

Fig. 10. T5: Path to success.

and errors that occurred, and a log of infrastructure activity (in case of responsive systems). One of the participants mentioned that this information could be encompassed in a secondary page for system health, with current data on the system, sensors, network load, data loss, among others. Furthermore, while all participants mentioned the importance of observing the space usage and indoor environment conditions over time, participants with administration or management background reported a preference for a dashboard that provided insights and trend analysis, in charts/visual representation, presenting patterns and trends on space usage, resource usage, spikes in occupancy, and cross-reference it with other collected data (schedules, IEQ, Wi-Fi speed, among others) to understand why these patterns occur, thus allowing users to easily make data-driven decisions.

In terms of frequency in access and task performing, the answers depended on how automated participants perceived the system to be, and the nature of the tasks: for instance, access motivated by issues and faults can vary from a few times a day to a few times a week, while gaining insights into facilities and resource use is premeditated and occasional. However, participants did not mention any tasks that would require them to have the dashboard opened and running on their devices throughout their working days, with the frequencies of access varying generally between once a day to once a week.

Besides the expected notifications and alerts on technical issues and warnings, some participants mentioned that warnings on unusual trends could be interesting; as an example, spikes of resource usage (higher energy use for prolonged periods of time).

Concerning the information that participants considered important to extract from the dashboard, weekly and monthly reports with above mentioned insights and trends were indicated, including a direct comparison with previous reports; in case the campus has multiple buildings, it would be important to compare the insights and patterns among them as well. A few of the participants indicated that such reports could be generated with the support of an AI tool, to obtain an initial qualitative analysis from the data, and reasoning on causes and solutions. The use of AI was also suggested as a facilitator for timely suggestions and insights on the data being processed in real-time.

Some participants also mentioned a booking service for meeting rooms and study rooms, with an associated feature of managing these bookings: a system that allows the administration to manage and override reservations (authorize, cancel, and move).

One of the participants, with a background in IT, raised the necessity of a ticketing system for maintenance; if multiple users have access to the same data, and the same warnings and faults, they should be able to claim/assign support and maintenance issues that arise, in order to avoid overlap. This suggestion aligned with other participants who indicated that the dashboard should allow administration and/or management to "flag malfunctions", "request repair or maintenance", and a "quick link to report a technical problem of a sensor, room equipment failure, or an AC malfunction". This would indicate a possible need to create roles for the users, and, depending on said roles, the dashboard would provide different options and features (in this case, creating a repair request versus receiving and fulfilling said request).

Data and Visuals. While the layout of the home screen was accepted by all participants, and considered "clean" and "easy to perceive", three participants indicated that the view of the room cards, with filtering and ordering, would suffice. The map would be relevant to view data represented by location, such as hotspots of noise, or patterns in movement. Removing the map/scheme was also preferred for the detailed view of spaces: students can move the tables (stations) to different places, rendering the scheme outdated.

In fact, when discussing their expectations on what should be prioritized for the dashboard's main screen, all participants expected quick, relevant data—the ability to perceive the overall status of the system in a quick glance, prioritizing insights on the conditions of campus spaces (rather than particular values for each metric and each space), and a general health status message (rather than an list of warnings and errors). While most prefer an initial view with quick visuals, using charts, color coding, or qualitative labels, a comprehensive view must be easily accessible.

As such, it may be necessary to adjust the dashboard main screen to a summary, rather than a comprehensive view of the campus, relocating the data to different pages. As mentioned previously, a system health page could hold the more comprehensive information on the sensors, status, network latency, data loss, and errors/warnings, while the main page conveys the general system status in a simple or qualitative manner. Similarly, insights produced from recently processed data should be added to the main screen, to integrate said summary.

The current access to the campus's historical data is on the home screen, while the historical data of each space is accessed on their own page, as explained in chapter 1.1. While participants found no issues, all data across the multiple campus spaces should be integrated and moved to a secondary page, to maintain consistency and to allow users to access all historical data in the same place.

In terms of data representation, participants preferred the use of graphs and charts to analyze the evolution of any metrics over time. Some also expected to be able to see data visualization on the map: (1) when in real-time, through labels and icons; (2) when viewing historical data, through heat maps and an auxiliary slider to control the time (to observe the evolution of the heat map over time).

Qualitative data (and processed numerical data, e.g. averages, percentages) were preferred as the default; raw numerical data would be optional or would not be immediately present at first glance. The aforementioned changes to the information architecture would address this preference.

The current possibility to choose the view in the pages was greatly valued, as was customization in general, particularly regarding historical data: participants valued the ability to view different charts and graph types, add or remove them, move and resize them, alike flexible containers with different possible configurations.

Customization is also relevant considering different roles of users present different tasks, and, consequently, different priorities on the system data and its representations.

It is important to note that a fully customizable product would require a higher initial effort from the user, and increased complexity in terms of product development. The alternative would be to provide ready-made, role-specific layouts and configurations to choose from. These presets would ensure consistent user experience, easier product maintenance, and a controlled flexibility through which the user sees the data in the format that's most relevant to them.

3.2 Application

The participants did not have free exploration time before performing the required tasks, as we intended to capture realistic first interactions, recreating a cold-start onboarding scenario. However, through observations during the sessions, we recognize that this may have led to increased clicks in the beginning of the tasks (in an exploratory fashion), and that being asked to perform a task with no prior knowledge may have led them to feel confused, stressed or rushed.

The first task required users to find Room 22, and view its details, by using the bottom menu, as depicted in the direct success (DS) flow of **Fig. 6**. Given that there was only one expected way to access the room page with the purpose of solely viewing its details, there was initial no indirect success (IS) path. However, as is visible in .

Table 1, three participants were able to open the Room 22 details view by through a different route; although this is considered an indirect success, in this case it demonstrated a misunderstanding of the UI by the users.

Table 1. Task 1 results.

	Direct Success	Indirect Success	Drop-off
Rate	60%	30%	10%
Average duration	19.4 s	64.1 s	121.8 s
Missclick rate	0%	37.4%	63.6%

That is, these participants immediately selected the + button under "My favorite spaces", and then attempted to open the card of Room 22 (which was not possible; in this screen, users can only add or remove from favorites), resulting in the increased missclick rate in IS. These participants then favorited Room 22 (flow visible in **Fig. 7**), and opened the room card from the favorites section in the home page.

The participant that was unable to complete the task (10% Drop-off rate) was also attempting a similar path, but an unexpected malfunction caused the prototype to fail.

Observations from this session indicated that these participants instinctively pressed the + button, and when questioned about it, indicated they "did not read the word Favorite", and did not realize there was a bottom menu. When questioned on changes that would mitigate this error, participants did not have any feedback. One participant explained they "rushed and did not see the whole screen"; another justified: "It's because it is on a computer. I believe if I would be looking at it on my phone, I would immediately look for a menu".

The second and third tasks had the goal of, respectively, adding and removing a room from their favorites (see DS and IS in Fig. 7 and Fig. 8). While both tasks had a 100% success rate (Table 2 and Table 3) we must note that four participants had already accessed this flow by mistake in the previous task. Participants did not express any issues or difficulties during this stage, and six participants mentioned these tasks were "easy" or "simple".

Table 2. Task 2 results.

	Direct Success	Indirect Success	Drop-off
Rate	100%	–	–
Average duration	16.4 s	–	–
Missclick rate	16.7%	–	–

Table 3. Task 3 results.

	Direct Success	Indirect Success	Drop-off
Rate	100%	–	–
Average duration	8.6 s	–	–
Missclick rate	0%	–	–

The fourth task required users to sign-up for an available workshop, either through the + button on the home screen, which was considered DS, or by accessing the listing of all events and workshops, selecting one available, and signing up for a IS (see Fig. 9). Observations during the sessions, and the results in Table 4, revealed that the participants had no issues with this task (null missclick rate, and reduced time to success). Two participants did choose the IS path, with the justifications that they “wanted to see what the page looked like”, and if they “wondered whether they could sign up from there”; this exploration could possibly stem from these sessions not including free-exploration time.

Table 4. Task 4 results.

	Direct Success	Indirect Success	Drop-off
Rate	90%	20%	–
Average duration	10.3 s	46.1 s	–
Missclick rate	0%	0%	–

In the final task, the goal was to change a particular notification setting, with the only possible path depicted in Fig. 10. While all users completed the task, we observe an increased missclick rate (see Table 5); in fact, the first click of 70% of participants was not the profile icon on the bottom screen, as per the DS path, but the bell icon on the top-right corner of the screen; in fact, one participant clicked that same icon five times before proceeding with the expected flow. At the time, it was clear that most participants instinctively selected Notifications icon to access its settings.

Table 5. Task 5 results.

	Direct Success	Indirect Success	Drop-off
Rate	100%	–	–
Average duration	11.84 s	–	–
Missclick rate	37.5%	–	–

Interestingly, five of those seven participants mentioned, as they proceeded and completed the task, that it was “logical” and “obvious” that the settings would be under the profile icon on the bottom screen.

To conclude the session, all participants were given the opportunity to provide any additional feedback, reflecting on their experience with the application. The majority of the users reported their satisfaction with their experience, and none referred any general dissatisfaction. Seven users reported that they were pleased with the visual appearance of the app, and eight were pleased with its “ease to use”. However, when asked about their experience with the first task, participants that completed with IS reiterated their comments, and one of the users added: “At first, I was confused on where to click because there’s an emphasis on the favorites section. It’s very visible, so I decided to click it”. Questioned further on this perceived emphasis, the participant asked to view the home screen again, adding “Now that I see it, it’s the same as the section below, but at the time seemed more prominent”. The results of the first task (see Table 1) merit particular attention in the next iteration, and it should be explored whether the position of title, or the font weight and size could be related to the observed confusion. Alternatively, the bottom menu may need to be emphasized, or another unrelated element can be place firstly, to remove favorite spaces from first position. Additionally, three participants requested that the notification settings should be reachable through both the bell icon, and the Profile icon. When asked whether it would be better to move its access solely to the bell icon, all reiterated that having both accesses would be preferrable.

4 Conclusion

The conducted user testing sessions of the proposed dashboard and smartphone app, as a digital products integrating a campus space monitoring solution, provided insights into the usability and the expectation of both systems, as a contribution to the project’s iterative design process.

Insights on the early design of the dashboard revealed that the information architecture should become more role-oriented, and should focus on categorizing and separating the different relevant data for users, rather than the current infrastructure-based architecture (i.e. the main page presents all data for the overall infrastructure, and the secondary pages present the data for a particular campus space, such a study room, a meeting room, or a common area). Thus, the dashboard should focus on summarizing key information on the main screen, and, in turn, detailed and raw data should be accessible through secondary pages dedicated to space usage, resource usage, and technical status. Users value mainly clear and quickly perceivable information, conveyed through charts, qualitative insights or calculated numerical values (rather than raw), but require an easy access to more comprehensive data and analysis, particularly participants with IT-related occupations. Additionally, participant feedback pointed to the need for customizable layouts based on user roles, which should be explored while maintaining a balance of customization and simplicity, to ensure the system remains accessible without overwhelming users (e.g. role-based presets). Participants also demonstrated an interest in incorporating AI-powered tools for data processing and data analysis, such as for generating reports or providing real-time insights and suggestions.

The application testing sessions, involving task performing through high-fidelity interactive wireframes, yielded generally positive results in terms of overall experience, visual design and ease of use. However, certain aspects merit particular attention in the following iteration, particularly (1) the placement and appearance of the favorites section, which may be perceived as prominent, highlighted, and a priority, confusing users on their first run/onboarding; (2) the location of the notifications settings, as some users suggested both the profile and bell icons as redundant pathways; to avoid said redundancy, this may be addressed by changing the architecture: profile is accessed through the user photo (on the home screen), and preferences/settings and support are accessed on the bottom menu, with a much clearer settings icon.

It is important to consider that this study involved a reduced sample size, with only ten participants for each proposed digital product; a larger, more diverse sample would help provide a more comprehensive understanding of user needs and preferences, reducing the potential for bias or skewed results, and improving user acceptance and engagement with similar solutions. Furthermore, the app testing sessions did not include an initial free exploration stage, which might have affected participants' first interactions with the app, possibly leading to confusion or rushed decisions. While the insights obtained through the reported user testing sessions may be valuable for similar initiatives in other educational institutions, such insights may not be generalizable to other universities. Further research in diverse university environments, and with a larger and broader sample, would greatly improve the scalability and adaptability of these findings to other initiatives and educational settings.

Acknowledgments. The study was supported by UNIDCOM under a grant from the Fundação para a Ciência e Tecnologia (FCT) No. UIDB/00711/2020 attributed to UNIDCOM – Unidade de Investigação em Design e Comunicação, Lisbon, Portugal.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

References

Abuarqoub, A., Abusaimeh, H., Hammoudeh, M., Uliyan, D., Abu-Hashem, M.A., Murad, S., Al-Jarrah, M., Al-Fayez, F.: A survey on internet of things enabled smart campus applications. In: ACM International Conference Proceeding Series, Part F130522 (2017)

Arunkumar, V., Rengarajan, V., Anand, V.V., Shreenivasan, K.A., Thiyagarajan, S., Swaminathan, R.: Impact of IOT on campus; smart student information system in the educational sector. J. Inform. Educ. Res., **4**. http://jier.org

Azizi, S., Nair, G., Rabiee, R., Olofsson, T.: Application of Internet of Things in academic buildings for space use efficiency using occupancy and booking data. Build. Environ. **186** (2020).https://doi.org/10.1016/j.buildenv.2020.107355

Gilman, E., et al.: Internet of things for smart spaces: a university campus case study. Sensors (Switzerland) **20**(13), 1–29 (2020). https://doi.org/10.3390/s20133716

Hicks, S., Huang, C., Lee, E., Patel, K., Vesonder, G.: Smart Campus for Better Study Spaces. In: 2021 IEEE 12th Annual Ubiquitous Computing, Electronics and Mobile Communication Conference, UEMCON 2021, pp. 325–327 (2021). https://doi.org/10.1109/UEMCON53757.2021.9666667

Liu, F., Chang-Richards, A., Wang, K.I.K., Dirks, K.N.: Critical indoor environmental factors affecting productivity: perspectives from university staff and postgraduate students. Build. Res. Inf. **51**(6), 730–745 (2023). https://doi.org/10.1080/09613218.2023.2204413

Madyatmadja, E.D., Yulia, T.R., Sembiring, D.J.M., Angin, S.M.B.P.: Iot usage on smart campus: a systematic literature review. In: International Journal of Emerging Technology and Advanced Engineering (Vol. 11, Issue 5, pp. 45–52). IJETAE Publication House (2021). https://doi.org/10.46338/IJETAE0521_06

Morgado, M., Ayanoglu, H., Soares de Lima, E.: Focus Group Insights into Student Experiences and Real-Time Data Visualization Expectations to Enhance Campus Life. In N. Martins & D. Brandão (eds.) Advances in Design and Digital Communication V. DIGICOM 2024. Springer Series in Design and Innovation, vol. 51, pp. 458–470. Springer (2025). https://doi.org/10.1007/978-3-031-77566-6

Muhamad, W., Kurniawan, N.B., Suhardi, Yazid, S.: Smart campus features, technologies, and applications: a systematic literature review. In: 2017 International Conference on Information Technology Systems and Innovation (ICITSI), pp. 384–391 (2017). https://doi.org/10.1109/ICITSI.2017.8267975

Rinaldi, S., Flammini, A., Tagliabue, L.C., Ciribini, A.L.C.: On the use of IoT Sensors for Indoor Conditions Assessment and Tuning of Occupancy Rates Models. In: 2018 IEEE International Workshop on Metrology for Industry 4.0 and IoT (2018). https://doi.org/10.1109/METROI4.2018.8428327

Valks, B., Arkesteijn, M.H., Koutamanis, A., den Heijer, A.C.: Towards a smart campus: supporting campus decisions with Internet of Things applications. Build. Res. Inf. **49**(1), 1–20 (2021). https://doi.org/10.1080/09613218.2020.1784702