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INDOOR MAPPING: IMPROVE THE QUALITY OF LIFE BY FORMING A SMART OFFICE SPACES

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***Summary.** The aim of the work is to study the theoretical foundations of indoors mapping for smart office formation, to improve the quality of life for Simon Kuznets KNUE students, staff and guests, to form the recommendations for the development and use of multilingual (Ukrainian / English) online app, which will guide the campus audience and obtain additional information.*

To achieve this goal there was done:

an analysis of the literature on modern types of interactive maps and modern methods of indoors mapping;

comparative analysis for choosing the most optimum software for work with the text information; work with graphics and images; software for creating an interactive multimedia map based on economic, technical, and software criteria;

comparative analyze of existing interactive maps of both domestic and foreign universities.

This analysis made it possible to establish the main characteristics of the design of all sections of the interactive map of Simon Kuznets KNUE, user interface design, main software needed, calculate the costs for developing of an interactive map of the university.

After the development and testing of the interactive map, an assessment of scientific and technical evaluation, cost-effectiveness, resource and social evaluation was carried out.

Keywords: *indoor mapping, smart office, interactive map, indoor positioning, competitiveness of the project.*

I. INTRODUCTION

In recent years, along with the improvement of smartphones technology and the expansion of Internet access, services based on the use of mobile devices for navigation and positioning have begun improve and expand much more faster. Such terms as location-based service, mobile cartography, and indoor mapping appear both in industry and in science. As an example, GoogleMaps launched a project IndoorGoogleMaps [1] in 2012 in the USA and Japan to find the right location in airports (boarding, rest areas, etc.), shopping malls (shops, food courts, play areas) and railway stations (search for the right track, navigation in land and underground crossings), which allows you to navigate indoors, develop complex routes in several languages. For today more than 35 countries have joined the project.

Today, the definition of "interactive map" is carried out through the term "indoor mapping". According to the OGC standard, indoor mapping is determined by the parameters of static and moving objects that help to position the user indoors [2, 3, 4]. Indoor mapping is a revolutionary concept that visualizes the room, spatial data and

people on a digital 2D or 3D map and allows you to determine the location in the room and navigate the object [5].

Georgios Pipelidis and Christian Prehofer from Munich Technical University [6] identified the main areas of use of indoor interactive maps to improve the quality of life:

internal telematics (navigation);

presence feature: allows the user to find friends nearby;

internal car communication: allows you to exchange warning messages, for example, to find empty parking spaces;

fleet management: control and coordination of the fleet of robots indoor.

The use of interactive indoor maps is advisable for:

virtual reality: can be combined with the real world, where the user's location will be an important aspect of the game;

hospitals: can locate portable equipment, navigate visitors and monitor the location of patients;

equipment monitoring: provides tools for identifying and reporting about the faulty equipment (eg burnt-out luminaires);

Internet of Things: making decisions about the location of user equipment;

assistance to firefighters: navigation of firefighters through safe areas or notifications about the people location in safe areas;

surveillance: tracking of children and pets, tracking of convicts or terrorists.

indoor evacuation simulation: conducting multi-agent indoor evacuation simulations.

Report of Markets and Markets [7, 8] estimates that the market for indoor location, including navigation, tracking data will cost \$ 41 billion by 2022. According to estimates of Opus Research [9], till 2014, about 200 startups worked on internal navigation systems.

II. LITERATURE ANALYSIS

2.1. Modern types of interactive maps

There is no single standardized type of interactive map for today. Each type differs both in design and in a set of functions. Each institution chooses a way to create a map according to current needs and capabilities. Such maps can be distributed according to the interactivity level and provided information:

map-schema - such maps contain only a plan of the premises and don't provide any additional information on the services located inside, for example, a map-schema of the NTUU "KPI" buildings [10]. Such schemes are often used for visual division of space, and are similar to fire safety plans. They provide minimal information, which is sometimes not enough for a calm movement in a building, especially if we have several multi-storey buildings that are connected to each other. Such a map oftenly can be printed out and used not online, but offline;

maps that contain additional information, such as a map of the shopping center "Caravan" with additional tips [1]. Such maps are very similar in structure to map-

schemes, but they have additional interactivity in the form of tips, ie additional information about the room, features and details, etc. can be highlighted.;

Maps with positioning and navigation tracking, for example University of Twente map with navigation [1]. The peculiarity of such maps is that they can determine the position of the user, and build routes indoors, and even outdoors between some buildings.

2.2. Modern methods of indoors mapping

Here are some of the most popular methods used for indoors mapping development:

JQuery + HTML. JQuery e-map plugins allow you to add interactive features tied to a specific location (for example, an interactive map created with Custom Interactive Map [11]). JQuery is a well-known Javascript library that is well known and used by web developers. Interactivity is one of the features of JQuery, which allows users to interact with the interface of the resource, and in this case with maps. JQuery e-map plugins are now widely used in modern web and smartphone apps.

CustomInteractiveMap-jQueryPlugin is used to turn a photo or vector graphics map into an interesting interactive app that is supported by all major browsers and works on all mobile devices. With this plugin we can create the interactive map.

This map allows you to not only animate the image, but also to divide the room into subgroups. The main disadvantage of this map - it's not good image animation for large and complex buildings, so it can be used for shopping centers that have a simple construction;

Programs for multimedia publications creation (AdobeCaptivate, Articulate, etc.);

ArticulateStoryline and AdobeCaptivate has been used for several years as the main tool for creating electronic multimedia publications (map of Washington Monuments created with ArticulateStoryline [12]).

These are multifunctional editors that allow you to create educational, interactive and even game content, interactive tasks, software simulations. Such apps are now often used to create courses and publications, but also other content, for example catalogs. It can also create interactive maps with search by word, show tooltips, and contain additional information.

It should be noted that such an app allows the finished product to embed into the site or use as an independent app, so this product will be multi-platform, and will work both online and offline.

Googlemaps. Google has launched the Building Schemes service. The service allows you to view floor plans of public buildings on Google Maps. Such buildings include railway stations, airports, shopping malls etc. Plans can be seen in the web version of the maps and in appstore for Android and iOS. You need only to find the building on the map and zoom it until the scheme appears.

If the user is inside the building and views the plan, his location will be indicated on the map with a blue dot. Inside the building you can make routes - for example, to the toilet or the room for mothers and childrens if you are at the airport or train station.

Users can replenish the database by downloading the building plan. You can do this by using the special link. The plan will appear on the maps after verification.

The service is very good for interactive maps creation, but it is not yet launched in Ukraine, so we can't work in it.

III. OBJECT, SUBJECT AND METHODS OF RESEARCH

University campuses are actively involved in the interactive mapping system, for example, the University of Seoul created a map of the campus in 2009, which is a hybrid of 2D (floor plans) and 3D (visualization); In 2012, the Norwegian University of Science and Technology created an interactive 2D map that allows you to navigate to the campus audience from anywhere in the city. It contains basic information about the institution (names of classrooms, technical rooms, etc.); Lausanne University of Technology has its own interactive map, it is also displayed in 2D, it, unlike the previous ones, you can't navigate around the campus, it only schematically shows the structure of the university and its audiences [13].

Creating an interactive map of the university is necessary for visitors (invited lecturers and specialists, media representatives etc.), foreign students, mobility students and teachers, freshmen who are poorly oriented in the building. Such a map can help not only in navigation, but also provide additional information about departments and services of the university [14, 15].

Thus, the aim of the work is to study the theoretical foundations of indoors mapping for smart office formation, to improve the quality of life for Simon Kuznets KNUE students, staff and guests, to form the recommendations for the development and use of multilingual (Ukrainian / English) online app, which will guide the campus audience and obtain additional information.

The object of research is the process of indoor mapping for the formation of virtual smart offices using the online app «Simon Kuznets KNUE Interactive Map».

The subject of the study is a set of principles, methods and design tools used to develop an online app «Simon Kuznets KNUE Interactive Map».

The main research methods used in the work: theoretical generalization (to study the concept of "interactive map", its characteristics and purpose, justification of the design decision of the interactive map, the formation of conclusions); comparative analysis (to identify the most effective method of interactive maps creation and related software).

IV. RESULTS

To develop a virtual space smart office using the online application «Simon Kuznets KNUE Interactive Map» it is necessary to choose the most optimum software for work with the text information; work with graphics and images; software for creating an interactive multimedia map based on economic, technical, and software criteria. In order to correctly choose the optimal program or service among the competitive options, a table is formed. 1 - 3 for the selection of individual working components on the basis of scoring (0 - the function is absent, 0.5 - the function does

not work properly, and 1 - the function is present in full), with one of the main evaluation criteria was free work with the product, because the project requires a high level of efficiency, the funds used should be minimized. Other criteria were selected depending on the software functionality required to operate.

Table 1. Choice of software for working with text

Parameter name	Microsoft Word	OpenDocument	GoogleDocs
Free license	0	1	1
Network binding	1	1	0
Group access	1	0	1
Change the orientation of the sheet	1	1	1
Installing the program	0	0	1
Total number of points	3	3	4

Table 2. Choice of software for working with graphics and images

Parameter name	AdobePhotoshop	CorelDraw	AdobeIllustrator
Creating graphics	1	1	1
File optimization	1	1	0
Color correction	1	0	0
Edit bitmap images	1	0.5	0.5
Resize	1	1	1
Free license	0	0	0
Total number of points	5	3.5	2.5

Table 3. Choosing software to create an interactive map

Parameter name	JQueryPlugin + HTML	Articulate 360	Googlemaps
Save the project in different formats	0	1	0
Use of interactive elements	1	1	0
Work products offline and online	1	1	1
Creating blocks of additional information	1	1	0
Availability of templates	0	1	0
Working with scripts	1	1	0

Using animations and effects	1	1	0
Available for work	1	1	0, does not operate on the territory of Ukraine
Connected to navigation systems	0	0	1
Free license	0	0	1
Total number of points	6	8	3

Thus, based on the results of comparative analysis, the following programs were selected to develop Simon Kuznets KNUE Interactive Map:

GoogleDocs online service provides free use of all the basic functions of working with text, such as: spell checking, using styles for editing text, applying layouts, quick editing tools, etc., which are also available in other text editors. It also has the function of group editing of documents, which is useful when several specialists are working on the project at once;

AdobePhotoshop graphics editor allows you to not only process selected images, but also optimize them to reduce the size of the project. The program can also create the necessary graphical elements of the interface and design of the project, such as: navigation buttons, additional elements and more;

You can use the Articulate 360 software environment to create an interactive map. Articulate 360 has a large number of built-in modules that make it easier to design.

For effective development of virtual space smart office with the help of the online application «Simon Kuznets KNUE Interactive Map» it is expedient to analyze the already existing interactive maps of both domestic and foreign universities. The following were selected for analysis: an interactive map of the University of Cambridge [16]; interactive map of Kyiv Polytechnic Institute [10]; interactive map of the National University of Water and Nature Management [17]. Comparison of selected interactive maps on the selected parameters on the basis of scoring (0 - the function is absent, 0.5 - the function does not work properly, and 1 - the function is present in full) are given in table. 4.

Table 4. Analysis of existing interactive maps of universities

Parameter name	Interactive map of Cambridge University	Interactive map of Kyiv Polytechnic Institute	Interactive map of the National University of Water and Nature Management
Availability of navigation with user position tracking	1	0	0
The complete scheme of internal premises of university	0.5	0	1

Additional information on functional rooms	0	0	1
Adaptability, for use on mobile devices	0	0	0
There are several navigation options in the application	0	0	1
Multilingualism	0	0	0
Availability of search function	1	0	0
Availability of direct communication with other external resources of the university	1	1	1
The presence of a change in the scale of the map	1	0	0
Visual representation of buildings on the map	0	1	1
Total number of points	4.5	2	5

The interactive map of the University of Cambridge offers a transition to the local network, so in no case is it intended to use navigation to track user positions. Ukrainian universities do not use this feature due to the need to connect to online maps, which requires additional financial resources to support this feature.

Complete scheme of the interior of the inherent interactive map of the National University of Water and Nature Management. Cambridge University on its map shows the interiors of only one-story buildings. The interactive map of KPI does not show all the interior of the building.

Additional information on functional premises, namely: departments, lecture halls, laboratories, other known different colours according to their functional purpose; on the interactive map there is a room numbering, only the interactive map of the National University of Water and Nature Management is inherent.

Developed Interactive maps for use separately on PC were analysed.

The interactive map of the National University of Water and Nature Management provides for the use of two navigation options. According to the first option, navigation is carried out using a graphics map depicting buildings in 2d space. When you click on the building, the internal scheme of the building of a particular floor opens. According to the second option, you can control the map through the built-in menu.

The analysed interactive maps are monolingual, developed in the state language of the country where the higher education institution is located.

The search function is present on the interactive map of Cambridge University. The search can be performed at the address of the building, by the name of the

premises, by the number of the auditorium. Ukrainian higher education institutions did not provide this function in their own interactive maps.

All analyzed interactive maps provide communication with other resources of the university, namely: the official website of the university, contact telephone numbers and e-mail addresses, etc.

The interactive map of the University of Cambridge allows you to zoom (zoom in / out) for a detailed view of the selected building and provides a more comfortable work with the map. Ukrainian higher education institutions did not provide this function in their own interactive maps.

Ukrainian higher education institutions have provided the function of visualizing the appearance of buildings in their own interactive maps, while foreign higher education institutions provide for the use of only the projection from above.

The interactive map of the National University of Water and Nature Management received 5 points by the method of scoring and can be considered a good example for the development of an interactive map of Simon Kuznets KNUE. Thus, the interactive map of Simon Kuznets KNUE should be informative, concise and intuitive, take into account current trends in the development of indoor maps, as well as the user experience, their perception of the product [18].

The interactive map should contain the following sections:

floor plans of buildings with the allocation of classrooms and functional rooms - in this section you can view the location of the auditorium, get acquainted with the internal architecture of university buildings, find structural units and background information about them;

reference information is a special section that explains the rules of using the map and resources of the application;

search - a tool for forming a request for the location of classrooms and departments of the university;

vertical menu - this block contains an alternative way to navigate the application;

services of Simon Kuznets KNUE - in this section you can get quick access to the main web resources of the university;

Feedback - Created to collect information about inconveniences found by users of the application.

The design of the user interface usually focuses on the primitives of the interaction operators (scaling, search, overlay, etc.) or on the general functions implemented in the interactive application that allow the user to manipulate the display [19].

The appearance of the interface design sets the tone for the entire user experience, starting with the mood and evoking an appropriate emotional response through improved usability and subjective satisfaction.

User interface design is a creative process, and creating a consistent and unique visual brand depends on iterative refinement of global design solutions (e.g., layout and quick response of the interface, application navigation, visual capabilities and feedback, color scheme, fonts) and local design solutions (such as information windows).

To achieve effective user interaction with the interactive map, it is necessary to apply the rules of interface design [13]:

satisfaction of universal convenience of use: recognition of needs of various users and development of design for plasticity that facilitates transformation of content;

sequences of actions must be grouped;

prevention of user errors;

formation of a system of easy cancellation of actions (user actions should be as reversible as possible);

reduce the load on the user's short-term memory: limiting the processing of human information in short-term memory requires a simplified interface.

Design of all sections of the interactive map of Simon Kuznets KhNUE must necessarily correspond to the unity style, which means the use of corporate colors of the university (blue, white, silver-gray), uniform design of functional elements, font design. The interactive map should not be overloaded with unnecessary functions and information, but look modern, stylish, intuitive. The attractiveness of the interactive map is ensured by the integration of controls, original design, use of corporate style, harmonious combination of colors, the presence of explanations in the form of graphic elements (Fig. 1). Convenience of registration of an interactive map and ease of use is carried out due to use of interactive elements, font and color registration details on which the user should pay attention are allocated.

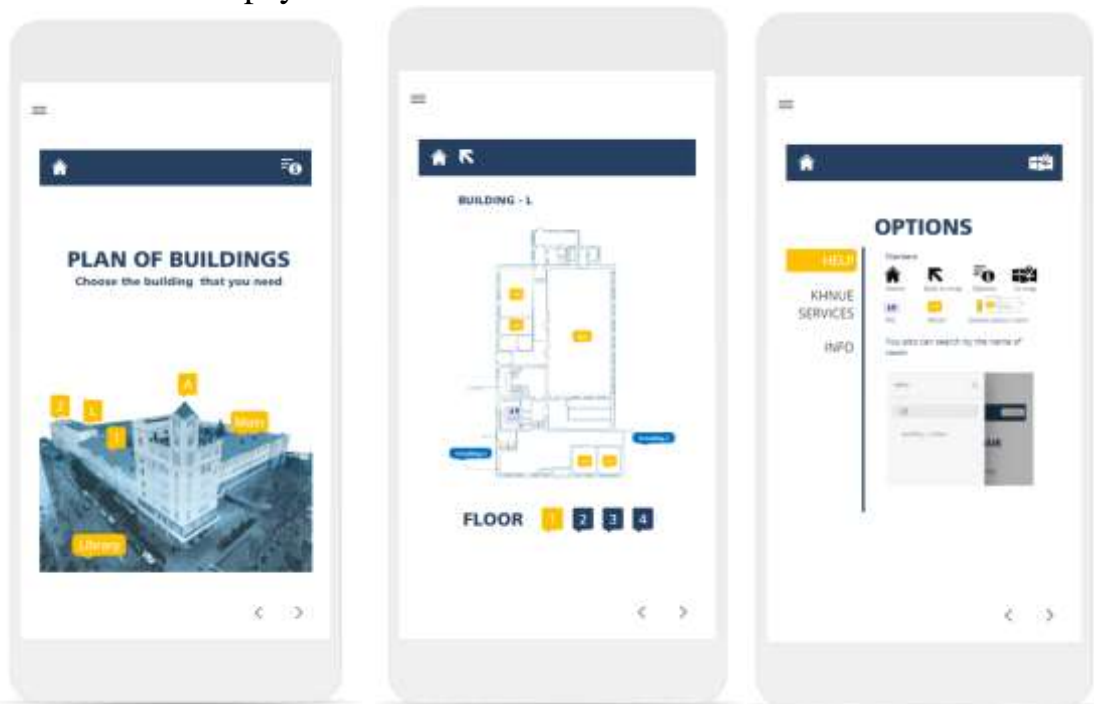


Fig. 1. Pages "University plan", "Plan of the 1st floor of the building-L", "Help"

All elements of the interactive map form a single composition, which is based on flat geometric shapes, right angles. The composition of the elements is stable and static, which gives the design the character of stability and balance.

Technical implementation of the interactive map of Simon Kuznets KNUE are made in the Articulate 360. This software allowed to carry out all set design tasks:

floor plans of buildings with the allocation of classrooms and functional rooms
 - bilingual map allows you to navigate the university;

reference information is necessary for the user to get acquainted with the rules of use of the application;

search allows you to find not only the audience of buildings by number, but also by keyword or element of the name;

a vertical menu divided into subcategories that include all the pages that exist in the application is an alternative way to navigate between pages.

interactive map associated with the services of Simon Kuznets KNUE (university website, personal educational systems website) and complements the network of university services;

Feedback allows you to contact the developer and inform him about the identified shortcomings.

The bilingual nature of the interactive map has led to the need to divide the software into two interconnected blocks, each of which has its own inter-page links, which are the basis for navigating the application.

The costs for developing an interactive map of the university are calculated according to the formed economic elements in accordance with the existing regulations of Ukraine [20].

There are no material costs in developing an interactive map of the university.

To determine the cost of labor, the calculation of labor costs and wages in accordance with the median average monthly salary of the developer of multimedia publications, who has the skills to work in Articulate 360 entry level. According to surveys by DOU.ua [21], the monthly salary of a entry-level developer of multimedia publications in Kharkiv is UAH 11,300 (for 8 working hours during 22 working days; rate per hour UAH 64.20) (Table 5).

Table 5. Calculation of labor costs and wages

List of activities	Labor intensity of works, hours	The amount of salary, UAH
Conceptual stage		
analysis of potential audience, its interaction with the product	6	385,20
analysis of the field of design and functional features of the product	12	770,40
script creation	4	256,80
Project planning stage		
designing the structure of an interactive map	7	449,7
designing the layout of the title page of the interactive map	6	385,20

designing layouts of internal pages of an interactive map	28	1797,60
Design stage		
development of a graphic solution and design of the title page of the interactive map based on the developed layout	6	385,20
development of a graphic solution and design of internal pages of an interactive map based on the developed layouts	28	1797,60
creating the necessary graphic elements	14	898,60
Functional stage		
designing pages using Articulate 360	6	385,20
installation, debugging and configuration of the application system	8	513,60
refinement and optimization of functional modules and components	3	192,6
Testing stage		
beta testing	4	256,80
amendments and refinements	4	256,80
Operational stage		
publishing an interactive map online	2	128,40
Total	138	8859,6

Deductions for compulsory state social insurance amount to 22% of the payroll, thus, their amount will be UAH 1,949.11.

The element "Depreciation" includes the amount of accrued depreciation of fixed assets, intangible assets and other non-current tangible assets. To develop an interactive map, you need the following equipment: AcerSwift 5 laptop; Articulate 360 software; graphic vector editor AdobeIllustrator; TP-Link TL-WR841N router. The amount of depreciation accrued during the development of the interactive map amounted to UAH 2503.83.

The element "Other operating expenses" includes the cost of: electricity used by the equipment; costs of water supply, drainage, lighting, heating; cost of communication services (high-speed Internet and telephone communication).

Thus, the cost of developing an interactive map of Simon Kuznets KhNUE are calculated in the amount of 15319.64 UAH.

The main criteria for evaluating the use of the interactive map of Simon Kuznets KNUE as an innovative product are the following [22, 23]:

relevance – shows the compliance of the innovative product to the goals of scientific, technical and socio-economic development of the organization. Goals are determined based on the established by the subject of management scientific, technical, economic, social, environmental priorities that can reflect global development trends and determine the strategy of the organization;

significance for the organization - characterizes the strengthening of its market position by solving technological, economic, social, environmental problems;

multifaceted - takes into account the impact of an innovative product on various aspects of the organization and its environment, obtaining different types of effect.

Scientific and technical evaluation of the interactive map of Simon Kuznets KNUE:

the selected technical solution for the development of an interactive map meets modern requirements in industrialized countries. Modern foreign, primarily European, higher education institutions develop and use various types of interactive maps, both indoor and campus maps. Ukrainian higher education institutions have also started to develop maps-schemes of the territory, but their level of interactivity is insignificant, and bilingual maps of interiors with the transition to information resources of the university are isolated;

developed an interactive map of Simon Kuznets KNUE are based on the use of modern software Articulate 360, which allowed to solve all the tasks of the project:

develop floor plans of buildings with the allocation of classrooms and functional rooms for navigation by the university;

generated reference information that the user needs to familiarize themselves with the rules of use of the application;

built-in search function, which allows you to find not only the audience of buildings by number, but also by keyword or name element;

built-in vertical menu divided into subcategories that include all pages, which is an alternative way to navigate between pages;

to connect an interactive map with the services of Simon Kuznets KNUE (website of the university, website of personal educational systems);

developed feedback that allows you to contact the developer and inform him about the identified shortcomings;

developed interactive map aimed at a wide range of consumers:

entrants who will be able to get acquainted with the university during the introductory campaign. The interactive map will facilitate their movement between buildings and will make it easier to find functional departments (office, accounting, dean's office, etc.);

first-year undergraduate students, part-time students who are not familiar with the university indoors and the location of functional departments and classrooms;

foreign students who do not speak Ukrainian to search the classrooms and functional departments of the university;

invited guests of the "Open door day", scientific and technical conferences, round tables and other public events held at the university, who are not familiar with the university indoors.

The cost-effectiveness of development is based on the cost of used rates of a novice developer. Also, in the open online services of application development agencies, a request was generated for the cost of an interactive map application similar in function. BuildFire offers a similar application for \$ 31,860; Cleveroad, a mobile application development company, is proposing a \$ 7,068 interactive map development task; Z1 Digital Digital Products Studio offers an interactive map worth \$ 60,100. Thus, the cost of own development (UAH 15319.64) is competitive in the market of these services.

Resource evaluation of the interactive map of Simon Kuznets KNUE is primarily concerned with improving the logistics of the flow of people during the busiest hours of public events (Open doors day, scientific and technical conferences, round tables, etc.), when there is a need to move university guests between buildings and classrooms. This interactive map can replace the system of direction indicators, which is usually used in determining the direction of movement to the main audience of a public event, but does not involve the use of indicators to the cafeteria, toilet, wardrobe and more.

Also, the interactive map can become an additional advertising product that complements printed advertising products, banners, branded products of the university.

Social evaluation of the interactive map of Simon Kuznets KNUE reflects the improvement of the quality of communications at the university.

V. CONCLUSIONS

The obtained results solve the problem of developing a multilingual (Ukrainian / English) online app based on Articulate 360, which will allow you to navigate in Simon Kuznets KNUE indoors and receive additional information about the university. This is especially valuable after the organizational changes at the university on 1.01.2021, when the names of individual departments and faculties were changed, the names and locations of departments were reorganized.

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