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A Mobile Application Project Supporting the MaaS Concept

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ABSTRACT

The aim of this article is to examine the possibilities of introducing the MaaS model in public transport. The MaaS acronym is translated as "mobility as a service" and refers to a type of service that allows its users to plan, book and pay within a single application and its integrated platform. This model has been developing dynamically in Western European countries and North America, significantly influencing changes in user behavior (resignation from private transport in favor of effective solutions such as bicycle and scooter rentals or car-sharing services such as Uber, Bolt, etc.). In order to check the users' readiness to introduce changes in the application, a survey was conducted, which indicated the direction of action and the acceptance of the proposed solutions. Over 80% of respondents indicated interest in the application, which provides access to many transport services in the Krakow area. The article identifies public transport user problems through selected research methods. Based on the applied research models such as persona, user flows, the application interface was proposed. Then, based on the design thinking problem, further tests will be conducted to refine and improve the application interface. In the final stage – the readiness phase, the offered prototype, after the required tests and the creation of a suitable platform, will be able to be gradually implemented for use by public transport participants. Therefore, further research supporting the application prototype is recommended.

Keywords: user, public transport, mobile application, mobility as a service.

INTRODUCTION

In recent years, a significant phenomenon of change in the modern travel model has been observed. This change is caused by the growth of cultural and social phenomena, and increasing social understanding of the acceptance of the shared transport model as a supplement to private transport within the sharing economy, which in turn results from the problem related to economic and spatial development. Technological progress contributes to the growing requirements for urban transport. These changes are the driving force for the introduction of more efficient ways of moving within urban transport, also taking into account micro mobility. An attempt to solve the emerging problem is to implement a sustainable transport policy, the goals of which are to support the development of mobile applications.

In the era of the dynamic development of the internet and mobile technologies, mobile applications are gaining new importance [1]. With a few gestures, the users of smartphones or any other mobile devices can easily get access to almost every area of life, from entertainment to shopping, or applications such as assistants and planners that improve and make their lives more convenient [2]. The increasing growth of technology and the competitiveness and capabilities of digital services have led users to expect products that meet their expectations [3]. Today's public transport users are no longer satisfied with a standard timetable showing the route, stops, and departure times of a given means of public transport. They are looking for products that make life easier and save time. That is where mobile applications came forward, which will not only help to find the schedule but will also navigate users around the city and

provide dynamic passenger information [4, 5] to keep the user informed of estimated departure.

Growing user awareness influences expectations and adjustment of the diverse service offer and its free choice, while optimizing time. Another initiator of the previously described changes is also the new MaaS business model, which allows combining many services and transport options, which places the needs of the traveler at its center. Needs that are also important from the point of view of UI/UX design in the spirit of design thinking.

Using numerous research methods to address the challenges posed by public transport users, this concept aims to meet the needs of the user with a single tool, e.g. an application that combines many offers from different carriers, navigation systems and payment technologies. An example of success in significantly reducing the use of individual transport are the Whim and Ubi-Go applications, which are the precursors to the creation of an application that allows planning and free choice in planning a trip, taking into account the needs of users.

Mobile applications for managing public transport

In urban transport, information plays a key role. It is with its help that it is possible to manage, plan and verify any problems that may occur during the journey [6]. It increases the quality of transport service and contributes to a better understanding of transport companies among passengers, which in turn affects customer satisfaction. The intended goal can be achieved by using solutions proposed by MaaS. They take the form of a digital platform and mobile applications. Among the mobile applications supporting the management of the transport system, based on the articles [6, 7], the following types of applications can be distinguished:

- calendar – shift,
- monitoring bus routes,
- controlling the number of passengers in the vehicle,
- used to evaluate drivers' work,
- issuing alarms (accidents, delays, interventions...),
- offering improvement in moving around the city (Google Maps, Yanosik),
- regarding the improvement of connections provided by public transport (Mobile MPK, My Bus),
- ensuring improvement and streamlining of the payment process (Sky Cash),
- supporting micro-mobility (bicycle, scooter).

Calendar-shift applications ensure smooth management of employee shifts of drivers, tram drivers, conductors or machinists, responding to the need of transport companies in planning within the application. By streamlining the flow of information and eliminating direct contact with interested parties, it creates a flexible schedule on an ongoing basis, covering all days off, breaks and holidays. The next type of application presented is those that deal with monitoring and tracking bus routes. These activities include both private transport and municipal companies. This is possible thanks to the use of GPS (Global Positioning System) technology installed in each of the aforementioned vehicles. This allows controllers to actually track and monitor vehicle movement, which affects early detection and information about random events or encountered problems. The advantages of this type of application are also noticeable by public transport passengers, who in this way receive a view of the bus route on a map, which provides them with information about waiting times and the duration of the trip. In order for the application to be useful, the information read from GPS should create a general and legible mapped image easily accessible to both passengers and controllers. It is important to ensure the appropriate appearance of the application interface, which would meet the requirements of user experience and user interface, which, when combined, would attract passengers to use the services of a specific carrier due to its simplicity, usability and visual layer.

Another solution using the GPS system is a type of application used to count the number of passengers. This type proved to be particularly useful in 2020/2021, when during the SARS-Cov-2 virus pandemic, restrictions were imposed on carriers regarding the number of passengers, which reduced earlier estimates to ⅓ of the people allowed by the manufacturer. Previously, this type of application was support for business analysis and to protect the carrier from penalties for failure to comply with the limits. As previously mentioned, the basis is a system integrated with onboard GPS and sensors that, mounted above the bus door (usually), show the number of people getting on and off and the possibility of assigning them to a specific bus. This application, again, as in

the case of calendar-shift applications, has found supporters among urban transport customers, increasing passenger satisfaction with the services of a given carrier, which is ensured by information about the current location of the bus. This information affects the trust and sense of security among passengers. Related to ensuring safety, in turn, are applications for evaluating the work of drivers. Their operation consists in replacing the physical documentation concerning the report from a given day by evaluating the work of drivers. For this purpose, an application is used, where on the basis of an appropriate form it would answer questions such as: whether the driver drove safely, whether he started the shift on time, whether there were any complaints, whether he was involved in an accident, if so, whether it was his fault, etc. These questions allow for a reliable assessment of the driver's work and may still indicate possibilities for improvement or bonuses. Closely related to the topic of safety are applications that alert about all kinds of urgent and independent situations such as accidents, delays, intervention or even weather conditions. This application would provide valuable information for early warning, which allows to avoid danger and inform about difficulties. The principle of operation would consist in sending a message via e-mail or text message when a previously described situation occurs. This message would go to a specially prepared group or platform, whose members would receive information. For the convenience of providing information, this application should be available on mobile devices, thanks to which the information will wait for a response much shorter than in the case of using non-mobile tools. The information provided should be automated enough that the basic data for subsequent reports is automatically completed in the form. After receiving the message, the person should send a response informing about the direction of further action. For better results, it could be integrated with a calendar-shift application, which would also provide information to previously described employees. This type of application reduces the number of emergency telephone calls, which would speed up the dissemination of information and the response to it [7].

Among the types of applications presented, it is also possible to divide them according to applications that help in moving around the city, which are the subject of the work. This type of application is commonly called a travel planner, which is a system that provides information at each stage of the journey while moving from one place to another. Their role is to search for connections by processing information about the transport offer of various carriers in such a way as to provide a ready proposal of connections for the user of this application. These proposals include: travel duration, time of arrival at the destination in the case of transfers, difficulties encountered, use of means of transport and providing an estimated price for the journey. This is possible thanks to the use of search algorithms in such planners, which, in combination with GPS, GSI (Grand Sport Injection), GPRS (General Packet Radio Service) systems, allow for locating the vehicle and mapping it to the area in which it is currently moving. Then, this data is selected in such a way that the total travel time is as short as possible, taking into account the preferences of users. They allow for searching for routes within the city, between them and sometimes also internationally. They also include intuitive, simple and clear access to information through a useful user interface. They provide certainty that the application user receives up-to-date and optimal information on the most attractive form of connection for them, which directly affects the growing trust and popularity of using this type of application. They are particularly helpful in the case of travel covering areas that the user is not sure about or does not know. Information provided by the interface according to [8] should include:

- start and end point in the form of: address, stop name, POI (point of interest); start or end time of the journey (recorded with date and time),
- taking into account additional preferences, e.g.: allowing for the exclusion of specific buses, bus line numbers, zone or express lines, etc., type of carrier, preferred lines or type of vehicle, e.g. low-floor,
- type of connection (convenient, optimal or a version when the most important thing is to get to the destination as quickly as possible, omitting convenience, time for transfers [8].

In addition, the search result received should include all the information needed during the journey, depending on the stage the user is at.

Sustainable urban mobility

The issue of sustainable urban mobility is a current, important and still gaining importance in the context of the idea of sustainable, contemporary development. It plays an important role in

ensuring the well-being of city dwellers, directly affecting the accessibility, safety, and comfort of travelers [9]. This term is understood as the ability to reach many places where a person intends to be at a given moment, but also the ability to plan a trip based on information that allows for its optimization. Sustainable urban mobility, on the other hand, attempts to solve problems related to the sustainable development of transport in urbanized areas, including the accessibility of movement for many groups of users. While maintaining low costs and time efficiency, resulting from the availability of public transport and micro mobility [10].

The concept of sustainable development grew out of the need to integrate environmental protection goals with the goals of other areas of life. Officially, this concept came into effect at the Earth Summit in Rio de Janeiro in 1992. Shortly thereafter, it became one of the main pillars of development, namely the first sustainable development strategy from 2001 - Environmental Protection Law. On this basis, many definitions of sustainable transport were created. According to observations [11], the definition created by the European Conference of Ministers of Transport (ECMT) is worth further consideration, according to which a sustainable transport system corresponds to the following sub-items:

- ensures the fulfilment of basic needs and the availability of communication purposes in a safe manner that does not threaten human health and the natural environment, in an equal manner for current and future generations,
- offers services at a price affordable for society, operates efficiently and fairly, offers the possibility of choosing a means of transport and supports a competitive economy and sustainable regional development,
- limits the emission of harmful substances and waste within the limits of the earth's ability to absorb them, uses renewable resources in quantities that can be regenerated, consumes non-renewable resources in quantities that can be replaced by renewable substitutes, while minimizing the impact on the use of space and noise emissions [11].

In addition, sustainable transport must be characterized by the following features:

- its functioning must have a positive impact on the health of society and improve the standard of living,
- preference for public transport over individual means of transport,
- consideration of the needs of both pedestrians and cyclists,
- at the stage of creating strategies, plans, and transport policy, local communities should play an important role,
- energy prices incurred in transport must take into account all costs, which will affect rational investment decisions,
- when planning the route of transport networks, the occurrence of naturally valuable areas should be taken into account [12.]

Sustainable transport has become the basis for the Sustainable Urban Mobility Plan (SUMP), a document that is intended to contribute to the implementation of European environmental protection and energy efficiency goals in cities [13]. The concept of the Sustainable Urban Mobility Plan (SUMP) aims at a 'new planning paradigm' in mobility, which comprehends a shift from planning for motorised roads and infrastructure to planning for people [14]. SUMP's approach has been widely recognised, targeting sustainable and integrative planning processes to deal with the complexity and dynamicity of urban mobility [15]. Hence, it embraces new modes of transport, e.g. micromobility, automated and connected vehicles and new concepts such as MaaS, shared mobility and so on. The concept of SUMP comprehends the integration of all modes of transport, public and private, motorised and nonmotorised and a long-term planning vision. It targets to improve mobility accessibility, sustainability and citizens' well-being [17].

Traditional planning focuses mainly on building infrastructure, with the aim of supporting it with more cars and increased traffic. While SUMP focuses on people. This makes transport more attractive both for users and from the environmental point of view. By including all activities aimed at reducing the common problem of pollution and traffic congestion. Another significant difference is the prioritization of short-term solutions, which, compared to SUMP, do not provide long-term benefits, such as improving public transport systems and making cities better for pedestrians and micro mobility solutions (bicycles, scooters). In addition, it should be clearly noted that the impact assessment, unlike traditional methods, is iterative, which means continuous monitoring, evaluation and a constantly improved process

Table 1. Comparison of the SUMP method with the traditional planning method [10, 12]

Traditional approach to transport planning	SUMP methodology
Focus on movement	Focus on people
Focus on means of transport; ensuring high transport capacity and speed	Improving the accessibility of means of transport and improving the quality of life, balancing economic efficiency, ensuring social equality, health and a high quality of the natural environment
Focus on infrastructure	Integrated action aimed at achieving effective solutions
Sectoral planning	Interdisciplinary and integrated planning that also takes into account urban policy areas such as spatial planning, social services and health, etc.
Short and medium term planning	Long-term, strategic planning
It concerns the administrative boundaries of the city	Applies to functional boundaries, including commuting areas (obligatory)
The dominant share of traffic engineering and experts from various fields	Interdisciplinary planning
Focus on meeting formal requirements within a specified time	Striving to achieve a specific vision in the long term
Limited impact assessment	Intensive assessment and evaluative shaping of learning processes and the planning process

[11]. The prepared document – Sustainable Urban Mobility Plan – serves this purpose, indicating the main directions of mobility development, the adopted direction of changes and investments in the field of sustainable mobility. Indirectly, it provides a sustainable and user-friendly urban transport system.

The place of MaaS in sustainable urban mobility

The discussion elucidates the concept of SUMPs as a framework for sustainable and integrative planning in urban mobility, emphasising the importance of embracing new modes of transport and innovative concepts like MaaS and shared mobility [16].

Technological progress contributes to the growing requirements for urban transport. Many cities were designed primarily for car transport, which in the long term leads to today's problems, especially visible in large cities such as Krakow or Warsaw. These cities struggle with a number of problems such as traffic congestion, road accidents, collisions, and also a negative impact on the air quality caused by, among others, pollution from transport [6]. As reported by [18], the second source, right after low emissions caused by burning in furnaces, is the deteriorating air quality due to transport. An excellent attempt to solve the emerging problem is the implementation of a sustainable transport policy, the goals of which are to support the development of mobile applications. The popularity of mobile applications indicates that smartphones have crept into our lives not only for service purposes, but also for navigation, supporting the travel process. This is possible through current access to location, timetables and other factors present during the journey and the implementation of the concept MaaS. Mobility as a Service is the integration of, and access to, different transport services (such as public transport, ride-sharing, car-sharing, bike-sharing, scooter-sharing, taxi, car rental, ride-hailing and so on) in one single digital mobility offer, with active mobility and an efficient public transport system as its basis. [19].

The MaaS provider role could be occupied by private, public, or both transport operators. The recommendation for them is to focus on providing integrated customer-centric data to the passengers. Public and private transport operators should work together as one integrator for MaaS services to define the standards for sharing data between all key stakeholders [20, 21].

Mobility as a service from a technological point of view is described as a comprehensive platform for managing journeys from one place (application) by various means of transport, which is mediated by a payment covering all the mentioned means, instead of a single payment for the service, regardless of whether it is transport in line with the development of the sharing economy or transport on demand (Mobility on demand). Below is Fig. 1 indicating the model of the functioning structure of stakeholders and services.

The presented block diagram shows individual elements and the contribution of stakeholders to individual blocks. Stakeholders are treated as

transport service providers, e.g.: bus companies, tram companies, train companies, etc., including micro-complementary transport integrated with the MaaS platform. It divides MaaS operators into: logistics and freight transport, public transport, e-Mobility, and air and sea transport, and shows their relationships. The system is based on data and API Technology for greater process efficiency, allowing, among others, personalization, facilitation of service of individual services and their improvement.

The MaaS model provides access from the application level to choose the most advantageous transport option, without having to move independently within other applications. An example of success for this type of mobility is the Whim application, which is the fastest growing product based on the MaaS concept. After conducting tests already in 2014, it contributed to a 21% reduction in the number of car journeys, thus confirming the main goal of the concept. Figure 2 below shows a simplified image of the MaaS concept.

This concept is relatively new, which is why there is ambiguity in defining its features. However, as indicated by [22] and [23], they point to:

- integration of transport modes,
- one platform,
- use of technology,
- the extent of involvement of entities,
- many different tariff options,
- demand orientation,
- registration requirement,
- personalization of services.

The possibility of configuring services is described in the context of integration: services, information, creating packages, ticketing and payments. It naturally becomes part of the Sustainable Urban Mobility Plan through direct integration with the SUMP principles and compliance with its phases. This integration can take place at one of 3 levels. These are successive levels, where the first includes partial integration, e.g. partially integrated ticket, payments and ICT, the next level increases integration by the level of advancement of ticket, payment and ICT integration and the last mentions advanced mobility packages. The latter are understood as creating such packages, the aim of which is to simplify access to mobility and the best possible use of different modes of transport [22, 23]. This is a solution for which the natural platform is the interface of a smartphone

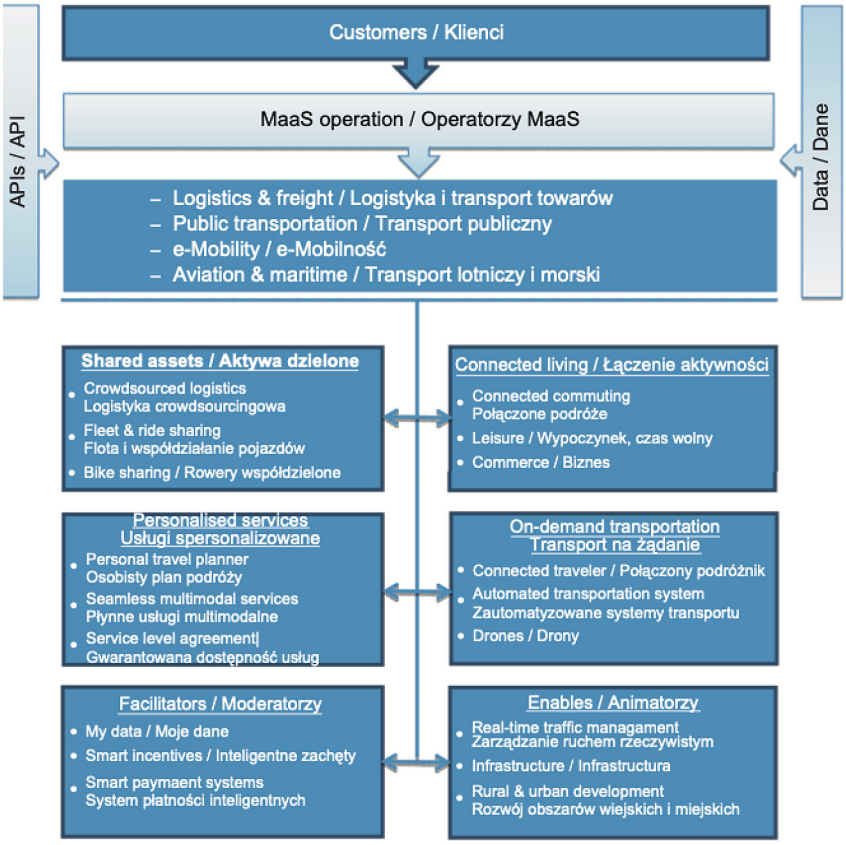

Figure 1. Comparison of the SUMP method [17]

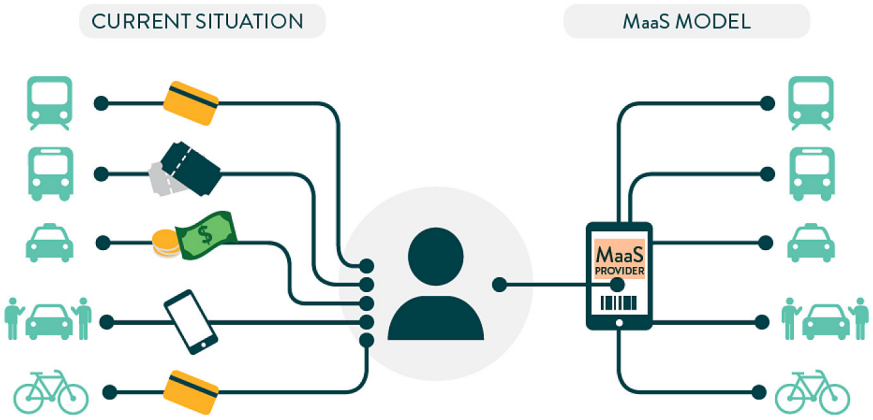

Figure 2. The essence of the system Mobility-as-a-Service [19]

or other mobile device, and a reference to HCD (Human Centered Design) keeping the human (in this case the traveler) in the center. In addition, the MaaS platform, due to its complexity and functionality, successfully fits into the Sustainable Development of Cities. The functions it has enable constant adaptation and control to changes in the context of travel planning.

For this reason, it is gaining increasing popularity around the world, including in European cities such as Stockholm and Helsinki, which already in 2016/2017 introduced tools supporting the development of MaaS, when it was impossible in Poland due to the lack of stakeholders fully reflecting the assumptions of the MaaS concept [24].

The main representatives of MaaS platforms are the Whim and UbiGo applications, whose main goal is to encourage residents to give up all or part of their private cars, which according to the concept were to be replaced by a flexible approach to public transport travel and its planning within a single application. The forerunner of MaaS was Helsinki, the capital of Finland, where sharing operations were introduced to the interface of a mobile application. This city decided to adopt a new transport strategy with an emphasis on technology. The initiation of the MaaS Global startup project led to the signing of agreements with transport operators. As a result, an application was developed, the aim of which is to integrate different modes of transport into one user-centric platform. Allowing from one place to plan, book and pay for all transport services, such as: public transport, taxis, car and bike sharing, which is mediated by a subscription model of fees. Many services are offered on the basis of cooperation with systems operated by different interfaces, for example: Taksi Hel-sinki, Lähitaksi and Menevä (taxi); Hertz, Sixt and Toyota (car rental); TIER (e-scooter) and JURO (shared bike).

Stockholm, on the other hand, offers its residents the UbiGo application, being a global leader in offering a wide range of means of transport. Already in the years 2017–2021, a project of an individual mobility service was implemented, within which access to management and distribution was offered. Like its counterpart from Helsinki, UbiGo has a subscription model in its offer, where within one integration it supports a shared account for family members. These users have access to planning, booking and paying for any trip within the city as part of the application. The functionality and usability of the application result from the programs with which it is equipped. These are: FluiGo IT tools responsible for the layer connecting the application with the user, in addition, the FluidBiz tool responsible for the subscription model and FluidHub, on the basis of which information about users is obtained. They concern preferences, behaviors, which allows for the detection of trends in the field of mobility, thanks to which this tool has the opportunity to develop and flexibly adapt to the mentioned needs.

Compared to foreign solutions, Poland currently does not have such extensive planned resources. A well-known attempt to introduce MaaS elements is the development and implementation of the Vooom application. This application allows you to choose a means of travel. Among the offers of various services and operators within one application, as indicated by the MaaS criteria. Constituting the third level of integration of transport services. However, this offer is not aimed at users of public transport who want to plan their journey, but rather at entrepreneurs who want to offer this choice to their employees in the form of a prepayment.

In reference to the MaaS Model in the context of public transport, there is the possibility of buying a public transport ticket. It should also be noted that the application producers do not express their willingness to provide users with shared transport and on-demand services at the moment [24].

The most common definition in Poland for MaaS is "an internet platform operating using cloud computing, integrating information about the journey from its beginning to its very end (door-to-door). Another example is the jakdojada.pl application, which offers a subscription model, which coincides with the assumptions of MaaS, however, apart from the possibility of payments within the application and recently intercity journeys, it does not currently offer integration with other means of transport. However, the closest application present on the Polish market is the Moovit application. According to its producers, it is considered to be the closest to the solution presented by MaaS. It offers multimodal transport planning using public transport as well as planning taking into account micro mobility.

MATERIAL AND METHODS

User experience design is carried out in the user-centered design trend, which in practice means designing with the user in mind. Based on the UX Double diamond process model, which is the most popular way of presenting the process. Design methodology developed by the Design Council, an organization dealing with design in the field of industry and economy in Great Britain [26]. As can be seen in the figure, the framework consists of four phases [25]:

- research phase,
- synthesis phase,
- ideation phase,
- implementation phase.

This finds its place regardless of the methodology and tools used. This process consists of two diamonds, one focusing on the problem and the other on its solution. Double diamond (Figure 3) is a framework of managing divergent and convergent thought models to create a flow between research, development and design techniques and is also used to create communication strategies [26, 27].

User Experience (UX) is defined as the whole of the user's feelings when using or imagining the situation of using a product, service, or system. Currently, providing the user with a pleasant interaction with the product is the basic task of the organization's employees. A multitude of solutions gives customers the opportunity to choose. The task of the company is to find a way to interest the customer in the product; this can be the appropriate design of the interaction.

One of the ways that the users will be more willing to employ is the designed system which applies the user motivation by showing the progress they have made. Currently, self-improvement and development are playing an increasingly important role. Observing progress motivates people to continue using the system. To sum up, the importance of User Experience design in

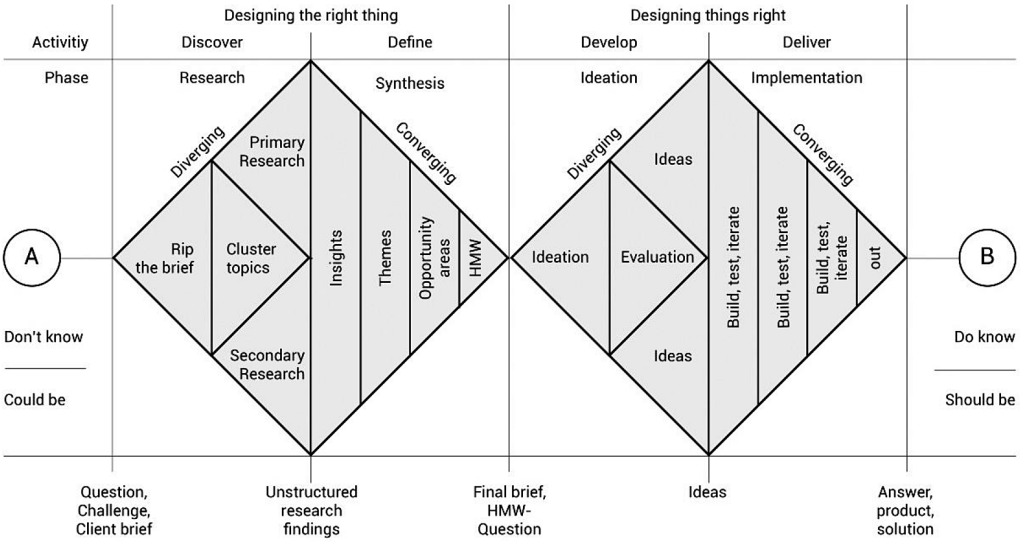

Figure 3. Double diamond framework [26]

applications nowadays is very high. The users have access to many products, but the pleasure of using them varies significantly. Thanks to the UX designer, the company can create a product that satisfies customer [28] (Figure 4).

The last method discussed in the discovery stage is survey research. This method also belongs to evaluation research, due to the possibility of collecting both qualitative and quantitative data. It is the oldest of the methods, providing objective information, but not too deep or extensive, especially in the case of examining a large number of respondents. The method of data collection can be divided into quantitative and qualitative surveys. The former, like the method from which they originate, collects data on quantity by checking appropriate boxes. The questions asked can be descriptive and causal in nature. The former provide insight into behaviors, attitudes and opinions, while causal ones are focused on comments, opinions aimed at determining the cause-effect relationship.

RESULTS AND MODEL PROPOSAL

The application of the research methods described in the previous chapter allowed the development of further visual models taking into account, among other things, user expectations. For this purpose, the approach of the following models will be presented: personas and customer journey maps, or information architecture.

Personas

User personas are a presentation of a user profile, providing information for designers about who the target group of users is. They serve to humanize the problem and search for solutions based on the example of people identified during the research [29]. The survey indicated the main types of users, these are people:

- using public transport every day,
- supporting their journey with micro-mobility solutions (scooter, bicycle),
- using intercity transport: buses, minibuses - users of personal cars,
- users of ride-sharing (Uber, Bolt).

Based on the survey and user interviews, the following example of a target user was specified. It should be mentioned here that in the case of such a study, more examples of personas are specified for each of the types listed above. However, for the purposes of this paper, a representative example is presented in Figure 5. The above persona indicates the goals to be met within the application:

- planning a trip using various means of transport, including micro mobility,
- real-time access to the application responsible for operating a scooter or bicycle,
- finding the shortest and most efficient route,
- receiving notifications about the current availability of individual means of transport in the event of delays, repairs, etc.

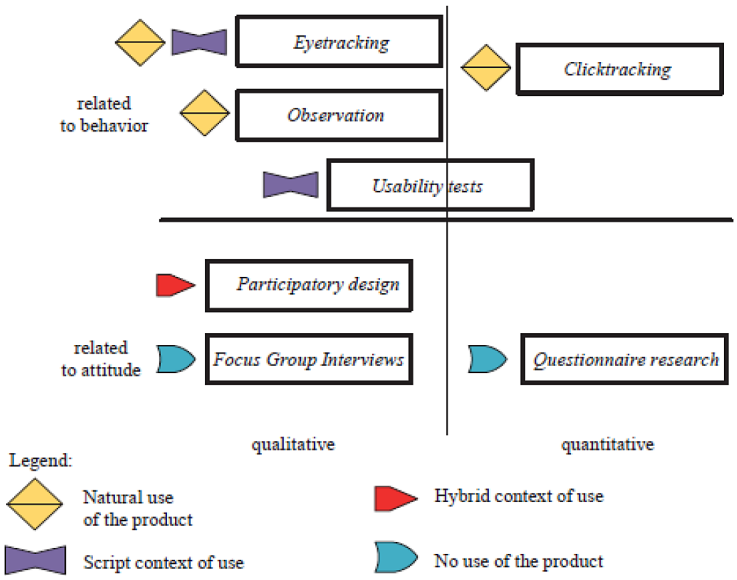

Figure 4. User research methods [28]

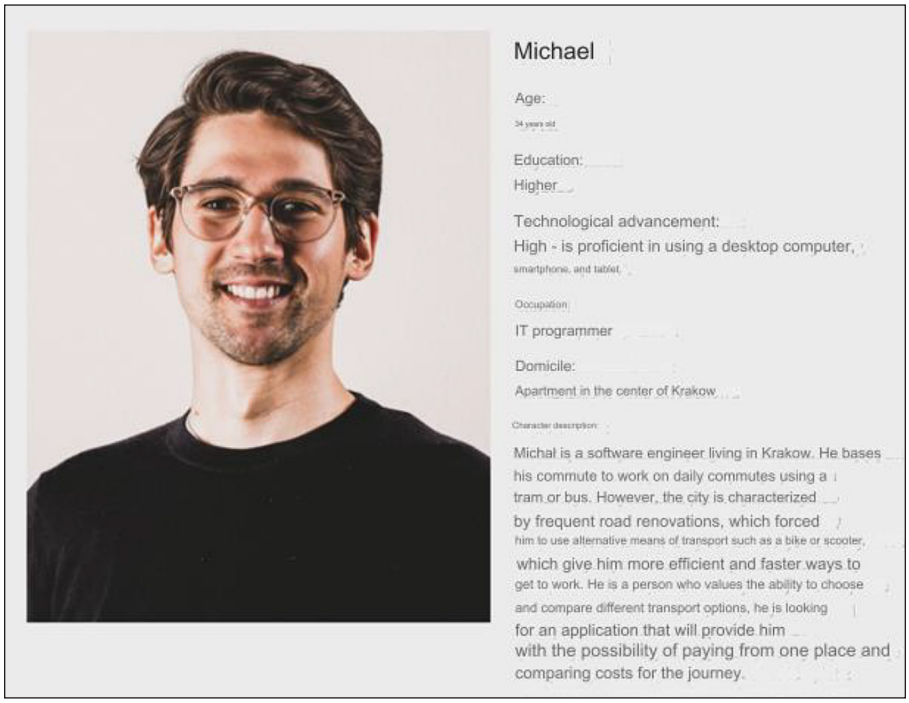

Figure 5. User

- user-friendly interface for planning a trip by combining multiple means of transport,
- receiving information about sustainable transport options and their impact on the environment.

Customer journey map

A customer journey map was created for the specified personas (Figure 6). Its purpose is to illustrate all the steps taken by users to achieve conversion. In this case, a conversion can be buying a ticket, choosing a specific route or comparing it. It also allows for referring to the context in which the product will be used. Below is an example of a customer journey map, it allows for illustrating the process performed by the user, which can indicate intuitiveness and influence the final information architecture and product development.

The basic element of the map is two axes, the horizontal axis represents the time axis and stages of the user journey, while the vertical axis concerns the components analyzed for individual personas. The time axis shows interactions that appear one after another, in this case these are interactions: after opening the application, during travel planning and choosing a means of transport and those concerning the selection of one of many means marked as route selection. The map also considers the payment stage. Each stage has been assigned actions taken on the side of the persona, goals, obstacles, accompanying emotions and ideas or opportunities. The encountered obstacles (pain points) indicate barriers that prevent the transition to subsequent actions within the application, while ideas and opportunities indicate possible changes in order to eliminate the barriers encountered by users.

Information architecture

The creation of information architecture is facilitated by the previously mentioned research method of card sorting and field research consisting of simple observation of potential users in their natural environment. It indicates how information, photos, data, tasks and actions the user can take. How they use the structured system to achieve their goals. For this reason, the application designer must once again assess who the customers of the designed solution are and what they want to achieve, what the persona and customer journey map were for. With all the information collected, i.e.: competition analysis, including the analysed competition architecture and personas, and established conversion goals, it is possible to start creating information architecture (Figure 7).

Based on this, an interface is created that also contains navigation. The above figure indicates the components of the navigation interface,

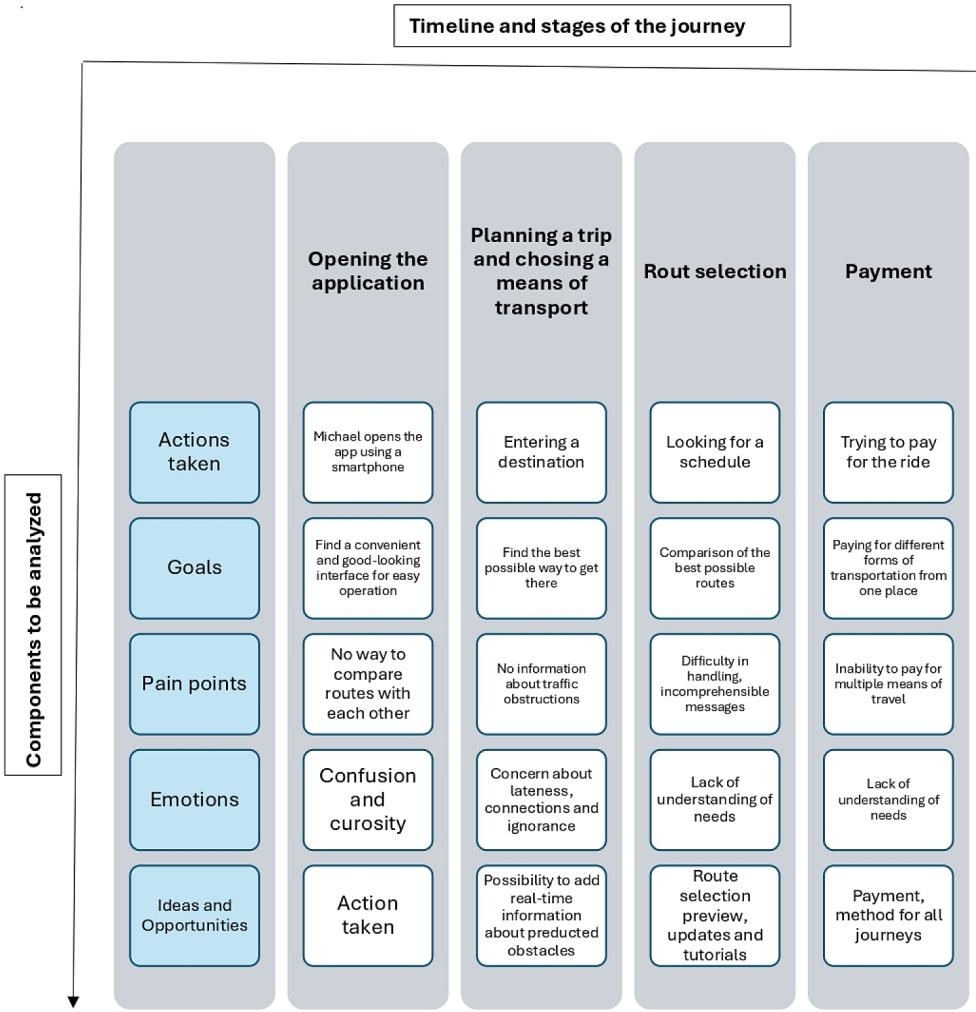

Figure 6. Customer journey map

represented by the taskbar located at the bottom of each application. In this case, from this place it is possible to go to one of the 4 main subpages: route, timetable, ticket and user profile, and from them to additional structured subpages as shown in Figure 7.

Interface proposal

Based on the above-mentioned research results, after creating research models, it is possible to finalize the project that is to support the MaaS service. For this purpose, the Figma application was used, which is currently the most respected and popular solution among designers for prototyping both websites and mobile screens. It allowed the creation of an application prototype, supported by a design system created for Android-based applications. For this reason, the most popular – material.io was used, containing both tips on user experience (UX) and user interface (UI) components. The created interface was supported and based on the components contained in the library of components shared through the Figma community.

As part of the adopted methodology, it was necessary to create an interface from which it is possible to combine different travel options, aimed at encouraging more sustainable choices. With this in mind, the following proposals for hi-fi (high fidelity) screens were created (Figure 8).

The above interface view is a response to user problems related to the lack of an application on the market that allows for multiple transport options. This screen presents the possibility of finding a route, present in almost every application of this type, and two new sections. The first section presents recent journeys, from here the user can almost immediately see the last routes and re-order possible through the integration of offers providing passenger transport services in Krakow, these are: Uber, Tier, Lime, Bolt and others, as well as information available from the level of public

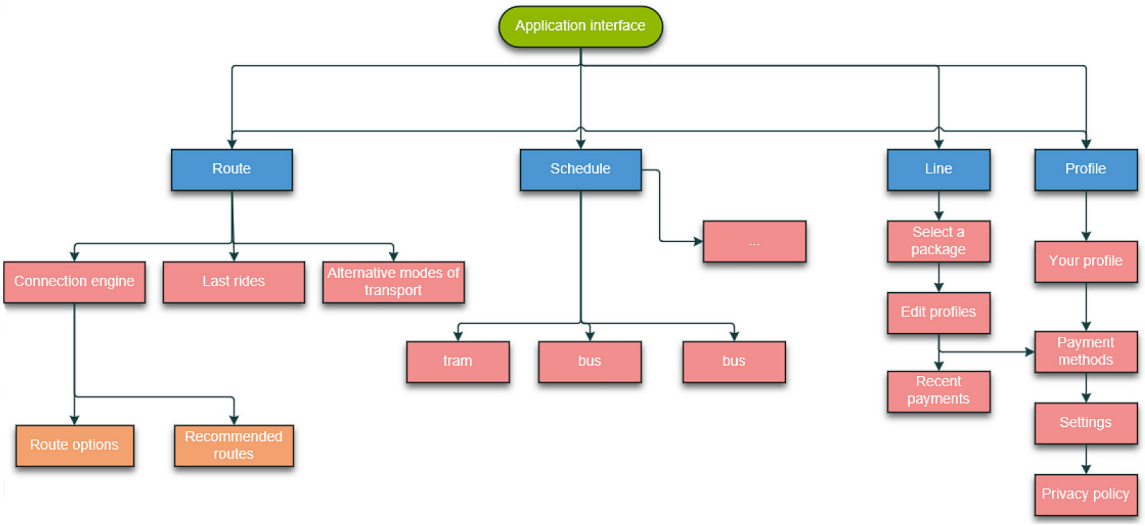

Figure 7. Information architecture

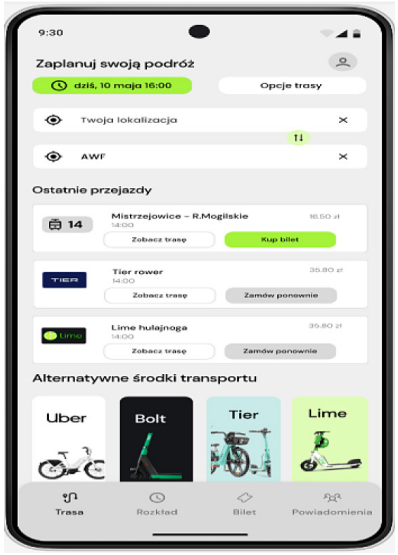

Figure 8. Home page view of the designed application

transport. The last section - alternative means of transport encourages the choice of micro mobility and allows you to go to the appropriate company websites (Figure 9).

The next screen is the one that allows you to compare possible routes, a novelty not offered by the application's competitors. Within it, after entering the destination, recommended routes and travel options are displayed. After clicking the selected option, another screen is displayed, where you can examine the route in more detail and change it by swiping the card located just above the bottom bar. This is also the screen for tracking the route live with the help of Google Maps. One of the most important aspects described within the application supporting the MaaS model, one of the assumptions of which was the need to make payments through the application for various means of transport and personalization and creation of a user account. The route options button and the user profile serve the purposes of personalizing the journey. Payment is available by selecting a specific service package by users, within which after adding a payment method it is possible to pay for various means of transport as indicated in Figure 11, where the section last payments displays the services used along with their price.

DISCUSSION

For research purposes, a study of public transport users was conducted in the form of a survey shared on popular social media using a created Google form. The questionnaire contained 20 questions. The subject of the conducted research is to check the readiness for the implementation of a mobile application development project providing integrated mobility as a MaaS service. Its aim is to combine the offers of various public transport carriers, micro mobility (scooters, bicycles) within one system covering numerous interactions. The collected data will be used to propose solutions for the user interface that meet the goals of users.

Identification UX problems

The survey involved 98 people aged between 18 and 70. The survey results are presented in

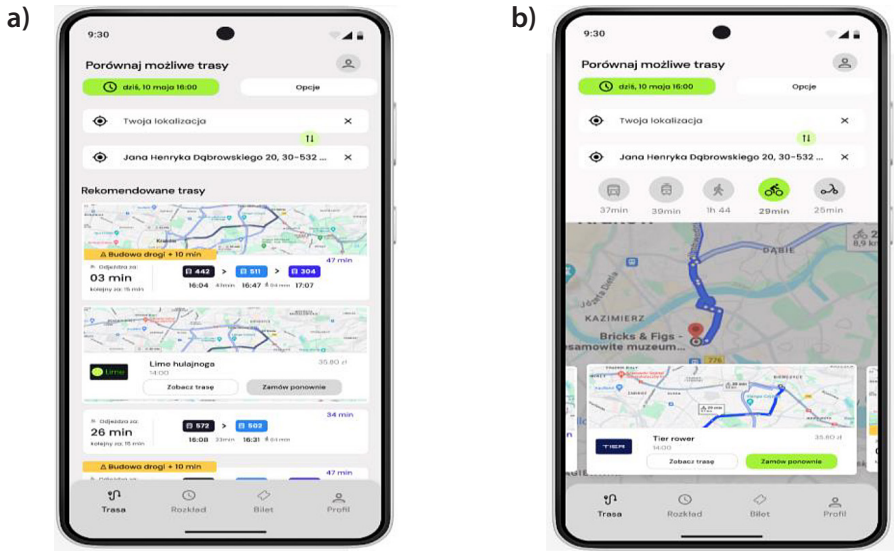

Figure 9. Comparison the route view at: (a) route view available from the main panel, (b) detailed view of the recommended route

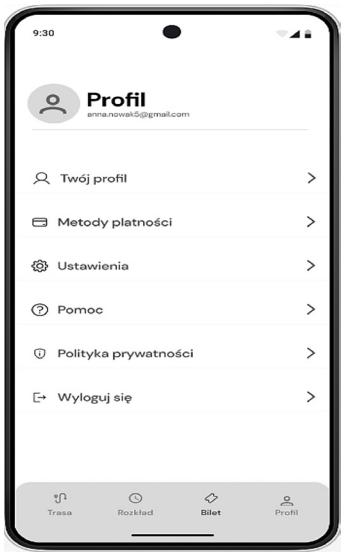

Figure 10. User profile view

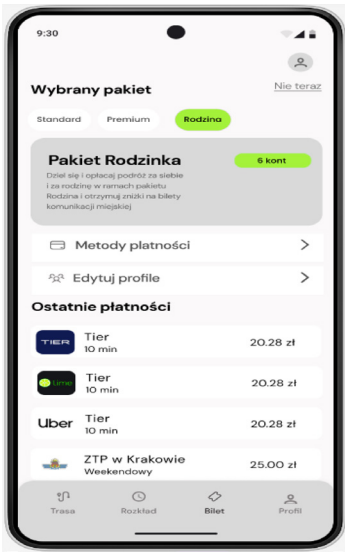

Figure 11. Ticket view – information about the selected subscription package

Figure 12. The participants of the survey were aged between 18 and 70, with the largest group (56.1%) being between 18 and 26 years old, mostly employes (57.1%) or students (33.7%) (Figure 13). The above question aimed to determine the proficiency in handling electronic devices and to find out which devices are most commonly chosen by users, helping to identify the interfaces worth designing for future digital products. The largest group of participants were smartphone users (100%), with a slightly smaller group (91 people) also using computers.

This question helps identify transport participants and choose integrations worth including in the app. The largest group (89.8%) uses public transport in the city. A smaller group (45.9%) are personal car users. The survey also indicated a demand for ride-sharing services (Uber/Bolt) (22.4%) and micro-mobility (12.2%). Single responses included car rentals (2%), motorcycles (1%), and bicycles chosen by 3 participants (Figure 16).

The above question was asked to determine preferences and highlight the most important factors when choosing a means of transport. The vast majority (37.3%) prioritize travel time, 21.6% consider comfort important, and another 21.6% focus on travel costs. A smaller group (17.6%) values the availability of different modes of transport, while

the smallest group (2%) finds environmental factors important. This question aims to identify research participants and check which group would be interested in improving the option of traveling by multiple modes of transport in a single journey. The participants were divided in their responses. The largest group (33.7%) said they use such transport sometimes (occasionally), 22.4% use it relatively frequently (several times a week), and 21.4% use it very often (Figure 18). Rating the level of satisfaction allows us to evaluate how satisfied users are with transport and indicates any need for improvement. The largest group (52%) rated the level of transport at 4, which is a relatively good result.

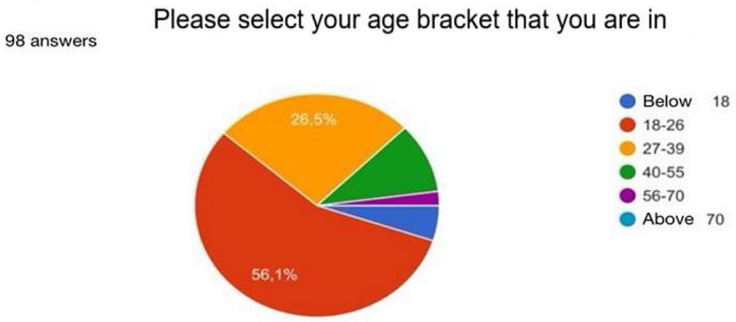

Figure 12. Chart showing the results of a survey generated in Google Forms

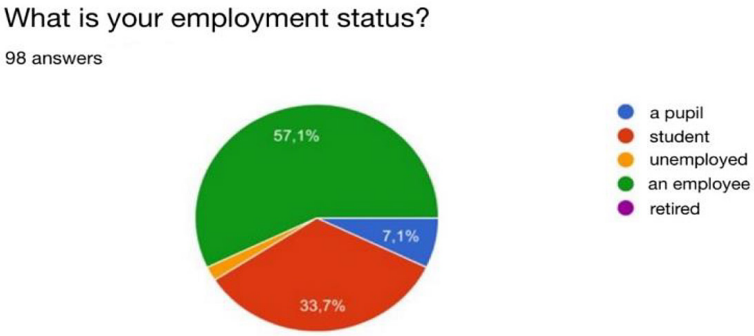

Figure 13. Employment status of the respondent

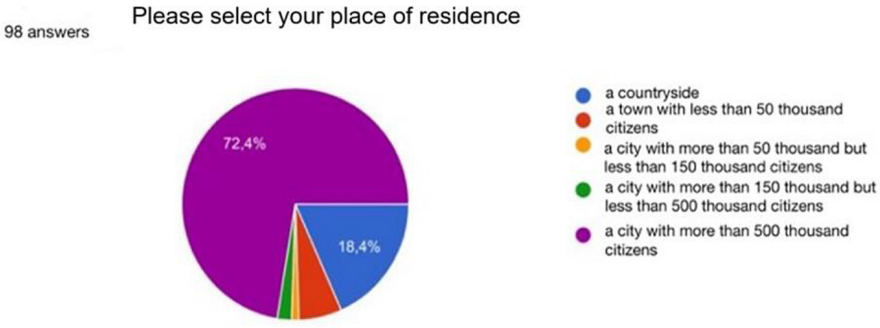

Figure 14. Respondent's area of residence

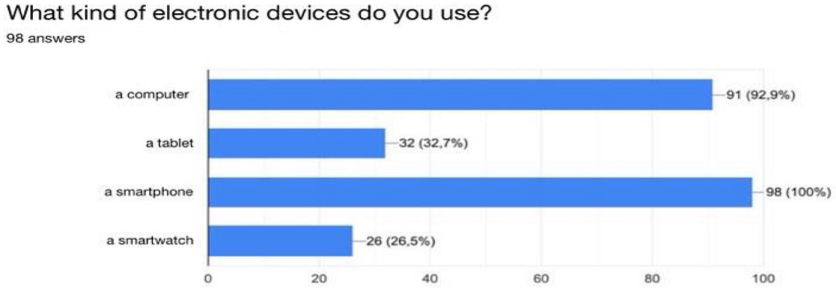

Figure 15. Type of electronic devices used by the respondent

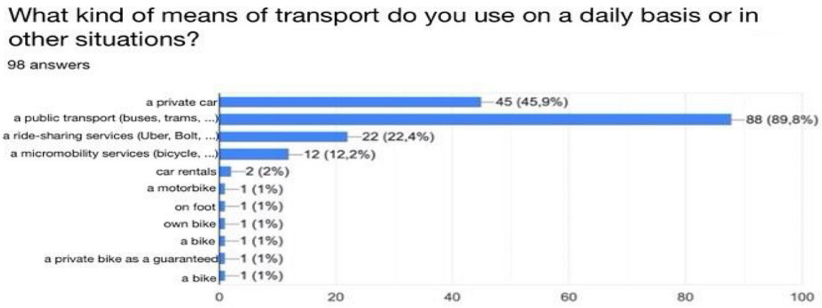

Figure 16. Type of mode of transport used by the respondent

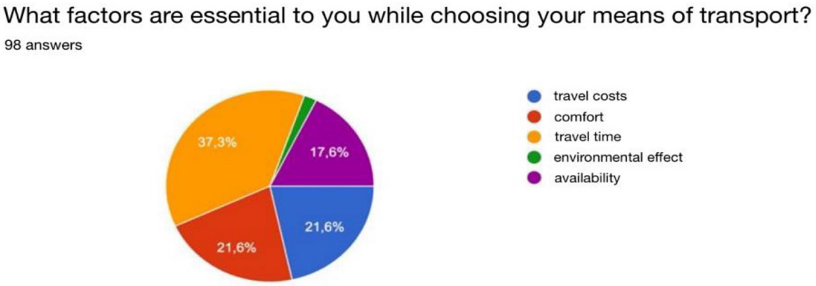

Figure 17. Main factors influencing the choice of mode of transport

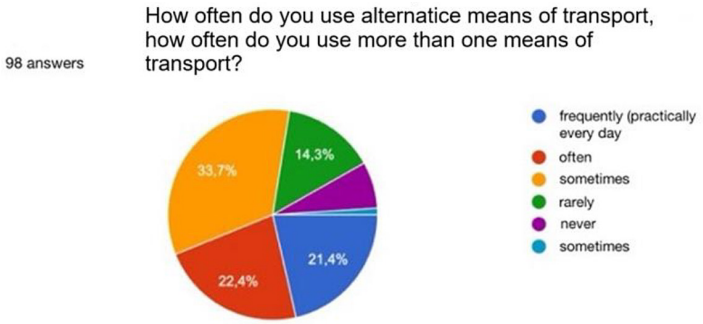

Figure 18. Frequency of use of alternative means of transportation

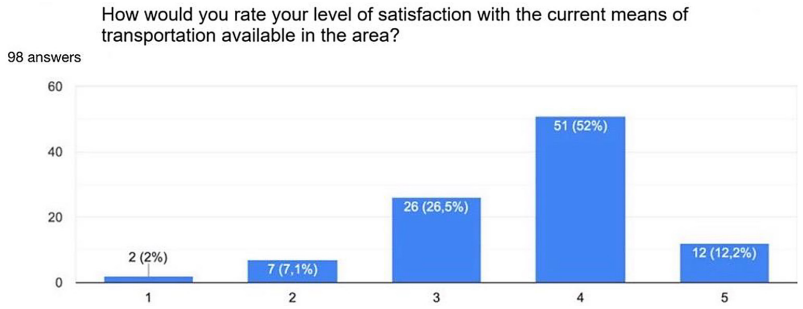

Figure 19. Level of user satisfaction with urban transport

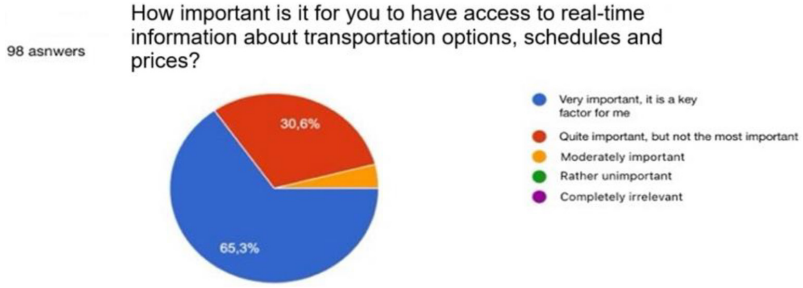

Figure 20. Respondent's level of importance to real-time information on transportation options, schedules and prices

A smaller group (26.5%) rated it at 3, indicating a need for changes in the current transport system (Figure 19). This question was asked to determine which features of an app are important to users. The largest group (65.3%) believes that real-time information on transport options, schedules, and prices is very important. A smaller group (30.6%) thinks it's quite important but not the most crucial.

Surveys have been conducted to find out users' opinions on the readiness to introduce a public transportation mobile application development project. Users often choose public transportation as their main mode of transport. The survey showed that the most important factor from the user's point of view is time optimization. There is a need to introduce solutions to support the use of public transportation, such as mobile applications. According to the respondents, the application interface should be simple, intuitive and easy to use.

CONCLUSIONS

The aim of the article was to examine the possibilities of introducing the MaaS model in public transport. This change is supported by the development of modern technologies and the growing popularity of mobile applications, which allow for greater integration of various means of transport, which were not possible before. These devices are everyday tools not only for service purposes, but also for navigation, supporting the travel process. Possible through current access to location, timetables and other factors present during the journey. The future is defined by the dominance of private cars caused by the growing population. These vehicles will need increasingly efficient infrastructure, which shows the growing needs of urban transport users in order to relieve the current infrastructure and the deteriorating air quality, especially in cities such as Krakow or Warsaw.

This concept aims to meet the needs of the user using a single tool, e.g. an application that combines many offers from different carriers, navigation systems and payment technologies. An attempt to introduce changes is the design of the application interface, aimed at encouraging urban transport users to use shared transport more often or simply more sustainable transport. However, it is impossible to introduce changes without checking the readiness of urban transport users for them.

For this purpose, a survey was conducted, which indicated the direction of action and the acceptance of the proposed solutions. Over 80% of respondents indicated interest in an application that provides access to many transport services in Krakow. The resulting work outlines the problems of urban transport users by identifying them using selected, presented research methods. On their basis, through research models such as: personas, user flows (user flow), the application interface was created, which due to the design thinking issues and related evaluation will serve further tests aimed at detection and improvement. Then, in the readiness phase, the offered prototype after conducting appropriate tests and creating a platform for this will be able to be gradually implemented in the lives of public transport users, for this reason further research is recommended.

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