Children's interactive car park

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Abstract. The authors of this paper propose a solution to the issue of improving road safety by more in-depth and advanced training of children in the rules of the road and driving a vehicle in the Children's interactive car Park. Within this Park, by taking into account accident statistics, driving license control exercises, certain features of the road network, etc., an urban environment in miniature is created that promotes full and practical learning for children. This system will allow children to learn from an early age what responsibility is on the road, become more attentive, which in turn will increase their safety in road conditions, as well as increase road safety in the future. This article describes the basic principles of developing a children's interactive car Park, presents its planning and organizational structure.

1. The current road situation

Modern trends in the growth of the level of motorization mediate the increased need to organize measures to improve road safety indicators, which is solved by planning solutions for the formation of the street and road network (calculation of geometric parameters, separation of flows of various road users through buffer and green zones, etc.) and technical means of regulation (road signs, markings, traffic light regulation) [1]. This indirectly addresses issues related directly to vehicle drivers, pedestrians, cyclists, and other road users, such as their mental and psychological state, specifically, their adequacy in assessing the road situation, their ability to understand risks, their understanding of their actions, and so on. Some habits and behavioral algorithms cannot be corrected only by technical means of regulation and planning techniques of the street network, because they are included in the complex concept of "driving culture", which is instilled in young pedestrians starting from childhood through examples of adult behavior [2], or already in the process of learning theoretical skills of road traffic Rules, driving a vehicle, etc.

This situation is confirmed by the statistics of insurance companies, stating the following: most often in road accidents, drivers are twenty-five to thirty years old, compared to other age categories. This is influenced by the combination of little driving experience, but at the same time confidence in your competence as a driver. It should be noted that road accidents committed by this age category are not considered serious [3]. Drivers aged forty-fifty years and thirty-forty years, respectively occupy the second and third places in this statistics. This may be due to the considerable experience acquired by drivers of the appropriate age and, as a result, excessive self-confidence and low vigilance on the road. Age, past experience, and other mental aspects lay down certain mental attitudes in a person that cannot be changed later (even by the rules of the road). Therefore, it is necessary to solve the problem by
preventing its occurrence, to educate future car owners to be responsible not only for themselves and for their transport, but also for other drivers, pedestrians and other road users.

2. Children's interactive car Park as a way to solve the problem of accidents
To address the psychological and physiological issues of training new personnel, a broader and in-depth program of driving training from an early age is required; this can be provided by the Authors' Children's interactive car Park. The program of using the Park includes working with children from four to eighteen years of age on the main aspects of behavior on the road: driving psychology, understanding and following the rules of the road, the theoretical foundations of the car and the ability to drive it. Thus, children will get the necessary knowledge and skills to successfully complete courses in driving school when obtaining a driver's license, acquire some personal qualities that increase their professionalism and suitability for driving a car, which will allow, when these factors are achieved, to improve road safety by forming an adequate road user: a generation of trained drivers, responsible pedestrians and careful cyclists [4].

To ensure that young visitors are fully immersed in the atmosphere of automobile driving, the interactive fleet includes all the most common elements of planning and organization of the road network, while causing maximum difficulties for both novice drivers and experienced drivers. The combination of elements involves not so much a sequential passage of exercises, but rather a simulation of the urban environment and real movements in it, according to social scenarios (the way from home to work, the way to the store, school, etc.). This approach will allow children to apply their skills in practice, without going to real city conditions, as is provided in driving schools [5]. The selection of elements is also supported by traffic accident statistics, based on the principle of the most frequent occurrence of accidents at a specific location. The data is based on the Ural Federal district; all major cities (Yekaterinburg, Chelyabinsk, and Tyumen) are accepted for consideration.

3. The structure of Children's car Park
Based on expert analysis, the main objects for the Children's interactive car Park are: a closed area equipped with control exercises based on elements of the street and road network; technical means of traffic management; a garage complex for placing training vehicles; a control point including a reception room for registering visitors, a staff rest room and other technical premises; a catering room; training and media areas, including classrooms, recreation rooms for visitors, etc.

Elements of the road network as the basis for exercises are defined in accordance with the current regulatory literature. In real conditions, each given object has its own calculated geometric characteristics determined by design standards, functional purpose, and other parameters. Figure 1 shows the relationship between planning and organizational elements of the road network. When selecting and setting the elements to be included in the project of a children's car Park, it was envisaged that not only motor transport would move in it, but also pedestrians and cyclists who are equally important visitors to the car Park as equal road users. To improve safety in the internal territory of the fleet, it is planned to separate the flows of various road users (pedestrians, cyclists, vehicles).
Figure 1 shows a diagram of the correspondence of road sections and exercises performed for the driving test. It is worth noting that these exercises do not always correspond to actual road conditions, but are designed to hone basic skills of driving vehicles [6]. In this regard, the street and road network of the children's car Park will combine two directions-basic test exercises and movement in sub real urban conditions; thus creating a quasi-urban space, by combining elements and filling functional zones with points of attraction.

Figure 1. Scheme of planning organization of Children's interactive car Park.
The combination of these elements will allow you to recreate traffic conditions in a quasi-urban environment, divide the territory of the fleet into functional zones designed to simulate everyday situations, and help young visitors to be in the place of a real driver. Additionally, paths for pedestrians and bicyclists are provided to provide scenarios for interaction between all road users [7].

4. Statistical analysis of road accidents
To identify the most problematic, and as a result, the most priority elements of the road network, the analysis of statistics of road accidents that occurred in the Ural Federal district was performed (table 1). These elements will be accepted on a mandatory basis when calculating and designing a children's interactive vehicle fleet [8].

Table 1. Ratio of road accidents by elements of the road network.

| Urals federal district | 2019 | Number of accidents | Wounded | Deaths |
|------------------------|------|----------------------|---------|--------|
| Intersection on the same level | 15 | 34 | 2 |
| Intersections in different levels | 5 | 8 | 0 |
| Ring | 24 | 38 | 3 |
| Contiguity | 5 | 9 | 1 |
| The narrowing of the band | 6 | 10 | 1 |
| Lane extension | 0 | 0 | 0 |
| Railway crossing | 0 | 0 | 0 |
| Dangerous turn | 18 | 25 | 5 |
| Pedestrian crossing | 12 | 17 | 3 |
Based on the data obtained, the ring intersection is the most dangerous section of the road network. Therefore, when working with children, this element will be given special attention to the rules of its passage, because ignorance or neglect of these rules is the cause of increased accidents at roundabouts. At the same level with the roundabout, a dangerous turn was detected, which mediates the adoption of equivalent measures and the development of the ability to control the car at speed with children [9].

Another important factor in the analysis of the street situation, when including its results in the project, is the statistics of road accidents involving children, due to the identification of the underlying causes of accidents and the degree of awareness of the child's actions (table 2) [10].

**Table 2. Accident statistics involving children.**

| Name of the parameter | Number of accidents | Wounded | Deaths |
|-----------------------|---------------------|---------|--------|
| 1. Accidents and injured children under the age of 16 | 399 | 6 | 446 |
| 1.1 With child passengers | | | |
| 1.1.1 Under 12 years of age | 233 | 3 | 279 |
| For violation by drivers of rules of transportation of children (without seat belts or child restraints) | 187 | 2 | 220 |
| 1.1.2 | 14 | 1 | 9 |
| 1.2 With pedestrian children | 113 | 0 | 115 |
| 1.2.1 Incidents at pedestrian crossings | 45 | 0 | 47 |
| 1.3 With children who are drivers of motor vehicles | 7 | 1 | 6 |
| 1.3.1 Including motor transport | 5 | 0 | 5 |
| 1.3.1.1 Of these mopeds and equivalent vehicles | 5 | 0 | 5 |
| 1.4 With child cyclists | 46 | 0 | 46 |
| 1.5 By their own carelessness | 96 | 1 | 96 |
| 1.5.1 With children pedestrians | 55 | 0 | 56 |
| 1.5.2 With children who are drivers of motor vehicles | 5 | 1 | 4 |
| 1.5.2.1 Including motor transport | 3 | 0 | 3 |
| 1.5.2.1.1 Of these mopeds and equivalent vehicles | 3 | 0 | 3 |
| 1.5.3 With child cyclists | 34 | 0 | 34 |
| 1.6 Due to traffic violations by drivers | 310 | 6 | 356 |
| 2. Accidents and injured children under the age of 18 | 476 | 6 | 537 |
| 2.1 Due to traffic violations by drivers | 376 | 6 | 436 |

According to these statistics, the following conclusions are made:

- Due to the frequent combination of various causes of road accidents, it becomes virtually impossible to track the absolute culprit of the accident, and therefore there is a numerical and percentage overlap of statistical data on accident indicators.
- 77.7% of road accidents were caused by drivers violating traffic rules.
- 24.1% of road accidents caused by pedestrian carelessness. From them:
  - 57.3% – pedestrians;
- 37.6% – cyclists (73.9% of all road accidents involving cyclists);
- 5.1% – children-drivers of mechanical transport.
- 58.4% with child passengers.
- 28.3% were child pedestrians, while 39.8% occurred at pedestrian crossings.
- 11.5% of child cyclists.
- 1.7% – children-drivers of fur. transport's.
- 83.8% – children under 16 years of age (78% – violation of traffic rules by drivers).

The analysis of statistics confirmed the lack of an appropriate level of responsibility for both drivers and children, together with reduced attentiveness in the latter, which at a young age also implies difficulties with understanding and, as a result, interaction with other road users, which creates emergency situations. Thus, training in the children's interactive car Park will help children develop the necessary care and awareness when driving independently in the city, develop skills of interaction with all road users and make the road safe [11].

On the example of the Junior Association of Automobile Schools in Russia can trace a downward trend in the number of road accidents with participation of children, through the operation of children's and youth schools, implementation in public areas and children's centers, as well as the organization of competitions in youth hosting a driving [12]. Thus, children learn the basic principles of traffic rules and vehicle management learn responsibility on the road. Table 3 shows statistics of road accidents involving children before and after the start of the youth driving school in the cities of Kazan and Rostov-on-don [13]. Based on this pattern, it is possible to predict a decrease in the number of accidents in this category after the use of a Children's car Park (for example, Tyumen).

Table 3. Accident statistics over the years and the tendency of its change.

| Accident category                                      | Quantity/Costs | 2017 | 2018 | 2019 | Trend, % |
|-------------------------------------------------------|----------------|------|------|------|----------|
|                                                       | Q  | D  | W  | Q  | D  | W  | Q  | D  | W  |
| Accidents and injured children under the age of 16     | 227| 2  | 286| 202| 4  | 279| 176| 4  | 243| -14| +50| -9 |
|                                                       | 159| 5  | 216| 124| 6  | 178| 74 | 4  | 131| -48| -17| -27|
| Rostov-on-don – there is a children's motor city and a youth driving school | Average trend of changes: | -31 | +17 | -18 |
|                                                       | Expected statistics of accidents in Tyumenafter the introduction of Children's interactive car Park | |
| Accident category                                      | Quantity/Costs | 2017 | 2018 | 2019 | 2020 |
|                                                        | Q  | D  | W  | Q  | D  | W  | Q  | D  | W  | Q  | D  | W  |
| Accidents and injured children under the age of 16     | 216| 1  | 332| 208| 1  | 333| 259| 4  | 375| 179| 5  | 308|
| Notes: Q – quantity; D – deaths; W – wounded.          |                |      |      |      |      |      |      |      |      |      |      |      |

A simulated urban environment within the conditional boundaries of the car Park will allow children to acquire the necessary basic skills of an attentive driver, a responsible pedestrian and a careful cyclist. At the same time, the experience of related organizations shows a decrease in the number of road accidents involving children.
accidents in regions where they work more intensively with children and adolescents, instilling a driving culture [14].

5. Analysis of the types of used vehicles

Due to the significant difference in the age of children and, as a result, their different abilities, skills and knowledge, it is necessary to consider different types of vehicles that correspond to the age groups of visitors. Today, there are many vehicles: from the car itself to alternative cars that copy its characteristics, appearance, or mechanics of operation. Each of them has its own advantages and disadvantages that determine the conditions for its use. Since the purpose of the Park is to directly train and involve future drivers, not only in the process of driving a vehicle, but also to comply with and understand the rules of the road, it is necessary to choose the type of cars that most fully reflect the essence of driving a car in urban conditions. Three options were accepted for consideration: a simple car (with a car engine), a car, and an electric car (figure 3).

![Figure 3. Types of vehicles: a – simple car, b – public car, c – electric car.](image)

To perform a lethal comparative analysis of all types of transport, a technical and economic analysis of vehicles was performed, including a comparison of their physical and mechanical characteristics, which will allow us to more fully consider the possibilities of their use (table 4). The most common models of each type of transport for 2019 were accepted for analysis.

| Name of parameter | Parameter value                                      |
|-------------------|-----------------------------------------------------|
| Engine            | Mini-car Sherhan Cruiser 4-stroke, 110 cm³           |
| Drive             | Car Lada Granta Chain 1.6 l                          |
|                   | Electromobile Harleybella Mercedes-Benz S63 2 x 35W |

Table 4. Technical and economic characteristics of vehicles.
| Brakes                  | Rear hydraulic disc, front disc | Front vented disc brakes, rear drum brakes | Drum             |
|------------------------|--------------------------------|---------------------------------------------|------------------|
| Power                  | 5.44 HP                        | 86 HP                                       | 35 W             |
| Max. speed             | 35 km/h                        | 172 km/h                                    | 7 km/h           |
| Ignition               | Contactless                    | With key                                    | With key         |
| Wheels                 | Tubeless, 18/9.5-8 or 235/30-10| 175/65/R14; 185/60/R14; 185/55/R15          | Rubber           |
| Power                  | 5.44 HP                        | 86 HP                                       | 35 W             |
| Max. speed             | 35 km/h                        | 172 km/h                                    | 7 km/h           |
| Ignition               | Contactless                    | With key                                    | With key         |
| Wheels                 | Tubeless, 18/9.5-8 or 235/30-10| 175/65/R14; 185/60/R14; 185/55/R15          | Rubber           |
| Gas tank/battery capacity | 7 l                          | 50 l                                        | 120 minutes      |
| Carrying               | 200 kg                         | 1075 kg                                     | 30 kg            |
| Transmission           | Semi-automatic (three forward speeds) with reverse | Mechanical (five forward speeds) with reverse |                 |
| Number of seats        | 2                              | 5                                           | 1                |
| Age                    | 7-11 years old                 | More than 12 years                          | 3-7 years old    |
| Overall dimensions     | 2000x900x740 mm                | 4268x2000x1600 mm                           | 1220x700x520 mm  |
| Weight                 | 160 kg                         | 1560 kg                                     | 16 kg            |
| Price                  | 196 500 RUB.                   | 399 900 RUB.                                | 12 500 RUB.      |

Based on the analysis of all the imperfections and advantages of the considered options for filling the fleet, a summary table of parameters has been compiled to justify measures for the use of each type of transport (table 5).

**Table 5. Analysis of the choice of the fleet.**

| Mini-car | Car                  | Electromobile                  |
|----------|----------------------|--------------------------------|
| 2000x900x740 | 4500x2000x1600 | 1400x850x800 |
| Relatively low speeds (up to 35 km/h), the presence of a speed limiter | Possibility to work together with an instructor | Low speeds (up to 10 km/h), the presence of a limiter speeds |
| The possibility of absolute control of an adult accompanying person | Direct access to the mechanics of the car | The possibility of absolute control of an adult accompanying person |
| Low cost of maintenance | Real driving conditions | Environmentally friendly |
| All-season | All-season | Low noise |
| Ability to pass all elements of the road network | | Low cost of purchase and maintenance |
| Negative characteristic | | |

According to the revealed data, the following conclusions can be drawn:
• All types of transport under consideration are accepted for inclusion in the vehicle fleet to ensure full coverage of all age categories of children; the dimensions of cars, mini-cars, and electric vehicles are taken into account in the calculation of elements of the road network.
• Critical differences in the physical and mechanical parameters of these modes of transport make it impossible to use them together. The solution of this issue will ensure the planning division of the zones of their use.

6. Programme of work of the Children's car Park
Based on the above conclusions, the dimensions of a real car and a children's electric car are taken into account for the design of interactive platforms. The initial program for working with visitors has also been developed:

• The entire territory of the children's interactive car Park is subject to traffic rules that apply to all visitors.
• Children under 7 years of age:
  ▪ Are only allowed on the territory of using electric vehicles under the supervision of an adult escort.
  ▪ The electric vehicle can be controlled directly by a child, or via the control panel by an adult.
• Children from 8 to 11 years of age:
  ▪ Allowed on the territory of using cars as a passenger/pedestrian/cyclist.
  ▪ Allowed as a driver on the territory of using mini-cars under the supervision of an adult escort.
  ▪ The mini-car can be controlled directly by a child, or via the control panel by an adult.
  ▪ Training trips with an instructor, educational lessons on the mechanics of the car are possible.
• Children from 12 years of age:
  ▪ Are allowed to use cars as a driver/passenger/pedestrian/cyclist.
  ▪ Training trips with an instructor, educational lessons on the mechanics of the car are possible.
  ▪ After passing the internal exam for a positive assessment, it is possible to allow the child to enter the territory of using an electric car as an escort.

This project has significant prospects for development and can become an experimental platform for testing innovative solutions, both in the field of construction and in the aspect of traffic management [15]. The use of new technologies and solutions is possible within the boundaries of the Children's interactive car Park, as in the conditions of the quasi-public road network of the city. At the same time, the car Park is an opportunity to organize individual tournaments and competitions in children's auto racing, which will attract both spectators and participants, mediating the mass character and interest of the younger generation in driving and learning the rules of the road. In general, it will contribute to the future development of literacy among future drivers by educating young road users to be careful and attentive on the roads.

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