Research Results of Possibility of Using Non-Traditional Materials in Design of Furniture for Children

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Abstract. The article considers the experience of studying the design capabilities of unconventional materials in the design process of children's furniture. Polycarbonate has been known for a long time, it is produced industrially and is mainly used in construction. It has good consumer and aesthetic qualities, high ductility, and relative cheapness. All this prompted a team of teachers and students to experiment in studying the possibilities of using polycarbonate in furniture for children. Children are very active and "destructive" in their activities. Not all furniture objects can withstand such loads, and those that withstand are often very expensive, because for children's institutions furniture is needed that would be durable and relatively cheap. The purpose of the experimental work is the design of children's furniture, taking into account the capabilities of non-traditional material, which meets the complex of modern requirements. The experimental work was carried out in three stages, on the first - the test material was corrugated cardboard, on the second - polystyrene, and on the third - polycarbonate. At each stage, a prototype was made and tested in a child care facility through operation for one month. Of the three materials studied, polycarbonate gave the best performance, which withstood all the mechanical loads of operation, retained its original shape, structural strength and external aesthetic appeal. The reviews of educators and employees of childcare facilities testify to the above qualities of the material and products made from it.

1. Introduction

In our country, there are quite a lot of furniture factories and firms specializing in the production of children's furniture work. In stores and supermarkets, customers are offered a wide range of different furniture products. Young families choose furniture for children; it is distinguished by brightness, convenience, but often performs only one function inherent in it. Another disadvantage of the proposed furniture, as a rule, is large or small sizes. To date, in our families there are 1-2 children who...
live and operate this furniture at home, as a rule, treating it very carefully. However, when it comes to more intensive use of furniture in large families or in children's institutions, it turns out that most of such furniture does not withstand increased operational load. The use of more durable materials increases the cost of the product, which is nevertheless calculated for a certain time period associated with the growing up of children. The relevance of our work stems from the need to search for new non-traditional materials for the manufacture of children's furniture, which would partially compensate for all the above disadvantages. In child care facilities, the operation of furniture has its own characteristics: it must be multifunctional, variable, and aesthetic and, of course, durable. These features arise from the daily routine when different functional processes are carried out in the same room: play, learning, eating, communicating, etc. In this case, the space should be transformed, first of all, due to the movement or transformation of furniture, hence the additional requirements for its design and materials. In the design process, the designer takes into account a whole range of requirements [25]: 1) functional - operational determining the purpose and scope of use of the product; 2) artistically - constructive, determining the shape of the product, design, their relationship between themselves and the environment; 3) technological, determining the manufacturing method and the materials used; 4) high-quality, characterizing the requirements for the process of artistic design, production and operation. By functional characteristics, the following groups of furniture can be distinguished: for lying, sitting, furniture - stand, furniture - storage and combined. In children's institutions, all of these groups are in demand. Verification of operational requirements of newly designed children's furniture should be carried out in conditions close to real. The artistic and design side of furniture is determined by the nature of the spatial organization of the form, the relationship of the main structural elements with each other, the choice of the contour of the product. For children's furniture color combinations are of great importance, sonorous, bright and positive colors are chosen here. Technological requirements are conditions that guarantee the operation of a product made of a certain material using the best technology. When designing furniture for mass production, it is important to take into account the industrial technological capabilities of production, best of all conveyor ones, as this will provide a fairly low cost and quick reproduction. The same requirements apply to children's furniture made of non-traditional materials. Thus, the hypothesis of our study is the assumption that already in the process of designing furniture for child care facilities it is necessary to look for new materials that are affordable and that provide multifunctionality, attractiveness and durability. The purpose of the experimental work is the design of children's furniture, taking into account the capabilities of non-traditional material, which meets the complex of modern requirements. To solve this goal and test the hypothesis, a set of methods was used to identify the characteristics of children's furniture from non-traditional materials and its testing.

2. Materials and methods of research
The basis of our work was a functional and technological study, which, being applied, allows us to obtain reliable and evidence-based information about the possibilities of using non-traditional materials in the design of children's furniture. The study involved teachers and students of the Design Department of Nosov Magnitogorsk State Technical University. They designed and manufactured prototypes of all products. Products were tested in two kindergartens in Magnitogorsk. The evaluation of the prototypes was attended by educators and leaders of these kindergartens.

The experimental work was carried out in three stages: the first stage - the study of the properties and design features of corrugated cardboard, foam, polycarbonate; the second stage - the manufacture of a prototype of a highchair from each material; the third stage is the observation of the use process and a comparison of the properties and design features of each prototype stool after the operational period. In the process of studying the properties of each material, we first carried out a theoretical study using different sources of information, and then empirically tested the properties of each material: cut, broke, bent, warmed, glued, pressed along and across, etc. Empirical experience formed the basis for the design of children's furniture and the manufacture of a prototype. They used the design method, a combination method, trial and error.
Testing was carried out on three samples and helped to compare the quality of the used unconventional materials. After the end of the operational period, the products were seized and evaluated. First, visually, then on a criteria scale (Table 1), which made it possible to assess the condition using a five-point system. The experts were employees, students and teachers who were not involved in the design and manufacture of these furniture units. Since polycarbonate showed the best performance, further work was continued with it. Students and teachers on the basis of already developed modules continued to design other furniture products that worked well in subsequent operation.

### 3. Discussion

To date, in theory and practice, several approaches to the use of non-traditional materials [4] in children's furniture are defined. Unfortunately, these approaches are developed by small enterprises or individual craftsmen who perform small series of items or piece products in general, and most importantly they hardly describe their experience. Often they work with one material, although designers need precisely comparative characteristics for the right choice. An important role for the use of such children's furniture would play calculations of the economic feasibility of serial production. At the level of state preschool institutions there are no prohibitions on the use of children's furniture [1] from non-traditional materials, because the way of the budget option of completing the subject filling of premises is relevant and quite realistic [6, 7].

### 4. Literary review

To date, the system of state children's institutions has been preserved and is actively developing. All of them work in accordance with regulatory documents. Design and construction of buildings, as well as the formation of the subject-spatial environment of interiors, is carried out in accordance with the requirements of [21, 22], legally enshrined in SNiP 11-64-80, GOST 19917-93, GOST 16371-93. However, this does not limit the ability of designers, including the use of new materials. The organization of the subject-spatial environment is widely covered in the works of V.T. Shimko, S.A. Khasiev, N.N. Kim, N.A. Morgun, and E.V. Sobolev. Some fewer works are devoted to the organization of the interiors of children's institutions and the role of furniture in shaping their comfort and safety. The experience of designing furniture is described in the scientific works of A.A. Bartashevich [5], V.D. Bogush, N.S. Zhdanova [2, 3, 8, and 9], V.F. Runge [19], Plotnikova M.M., Kosheleva N.A. [18] et al. The work of A.A. Grashin is of particular interest [6, 7], where the author offers the possibility of using modular combinatorial children's furniture. The market for materials for the manufacture of furniture is constantly evolving and updating. Each new raw material or technology expands the possibilities of furniture production, improves the operational characteristics and appearance of modern furniture, increases its functionality and, of course, expands the design range.

For our study, the experience of P. Zvonarev using non-traditional materials is important. [10], Ponomarenko L.V., Kantieva E.V., Chelebadze I.Z. [16, 17]. Best of all, in the scientific literature and Internet sources, the possibilities of using cardboard are reflected [20, 23, 24, and 25]. The review of the literature shows that the claimed trend in furniture design, on the one hand, is not fundamentally new, but on the other hand, in design, any option complements and extends the existing experience and, ultimately, leads to new design decisions.

### 5. Results

Children's institutions work according to a long-established and well-tested daily routine, which contributes to the proper development and maturation of the child. Traditionally, each group of children is allocated a block of premises in accordance with their age. In the same space, children are long enough. Various functional processes are carried out here: communication, game, learning, eating, etc. under each type of activity, space is transformed, first of all, due to the movement of
furniture and other subject content. Frequent movement imposes additional requirements on the design and content materials.

The team of teachers and students of Nosov Magnitogorsk State Technical University conducted experimental work to study and test in practice the possibilities of furniture made from various non-traditional materials [9].

Initially, at the first stage of the study, a theoretical study was conducted, special and regulatory literature on furniture was studied, then materials were selected, their properties and design features were clarified. Already at this stage, the team determined the furniture type taking into account the optimal operation: non-demountable, collapsible, folding, warehousing, transformable, etc. Then unconventional materials were chosen for the manufacture of the product cardboard, foam and polycarbonate.

To date, cardboard is considered to be almost any multilayer paper, the thickness of which is more than 0.2 mm. In our study, we used packaging cardboard (corrugated cardboard), which has the following properties: frame, rigidity, high level of strength and barrier properties. The structure of the packaging corrugated cardboard consists of several layers, which makes it more durable. The second investigated material was polystyrene. The foam acquires its characteristics due to its special structure. This is a granular material based on polystyrene. It contains up to 98% of air, while the volume of the dense structure does not exceed 2%, which means it is very light. This material has one drawback: low bending strength. The main advantages: low price, long service life, low weight, low level of hygroscopicity, resistance to high and low temperatures, resistance to the formation of fungus, lack of smell. The third material - polycarbonate - is a thermoplastic polymer that has no analogues among modern polymers. It has excellent parameters of light transmission, impact resistance and heat resistance. The properties of polycarbonate are practically independent of weather conditions: the critically low temperatures at which it can become brittle are outside the range of interior temperatures. Its hardness and resistance to compression are similar to aluminum - the reinforced multilayer monolithic polycarbonate is able to withstand even a shot from a firearm. In our work, we used structurally cellular polycarbonate - these are two (or more) layers of plates, between which longitudinal bridges are made — stiffeners. Having studied in theory the properties of the selected materials, we began the practical development of each of them. Different types of cardboard crumpled, bent, moistened, cut, broken, etc., we chose the packaging cardboard because it more met the necessary requirements: durable, multifunctional and affordable. Only after that they started designing a test sample of the product. When designing the product, the combinatorial - modular method was used. At the beginning of the twentieth century, the use of this method made it possible to intelligently organize living space. The interior has become mobile, economical and rational. A distinctive feature of the content was clear silhouettes, clarity of form and design. Modular furniture is a set of individual furniture elements that are made in the same style, have interchangeability and wide possibilities of variant combinations, transformations, transformations and constructor. For the constructive basis of the product, carcass profiles were chosen: an l-shaped plane that resembles a boomerang shape and a rectangular profile (Figure 1). Modules were made in stages from three materials selected by us - cardboard, polystyrene foam, polycarbonate. Cardboard was the easiest to process; the polystyrene crumpled during processing. Lattice-shaped polycarbonate modules were cut easily and precisely. The recesses helped to connect the modules - due to this, the design of the product became easier.

Figure 1. Drawing modules.  
Figure 2. Product design.
The prototypes performed by teachers and students [15] were tested by operation in kindergartens of the city. A cardboard sample showed the following results: “tough” operation lasted for 10 days, since it was subjected to wet processing. Structural qualities were lost - the cardboard structure was broken, and he began to lose his properties: frame, stiffness, level of strength and barrier properties. Aesthetic characteristics were also affected. A foam prototype was tested in a child care facility by operation for 20 days, and then it lost its structural strength. Partially, the structure of the foam was broken - parts of the sample broke off at the joints, corners, large pollution planes appeared, i.e. aesthetic qualities were lost. The third used polycarbonate. The prototype, as well as the two previous ones, was tested in a child care facility through operation (Figure 2). After the expiration of the term, it became obvious that the strength characteristics withstood the “tough” operation for 30 days; the structural, technical, technological and aesthetic qualities were not lost. The performance of the prototype was evaluated by teachers, students and educators. The results are demonstrated in Table 1.

| Materials       | Lifetime | Assessment at the beginning of the experiment | Conveni ence | Strength | Frequenc y of use | Assessment at the end of the experiment |
|-----------------|---------|-----------------------------------------------|--------------|----------|-------------------|----------------------------------------|
| cardboard       | 10 days | 5                                              | 4            | 3        | 5                 | 3                                      |
| styrofoam       | 20 days | 5                                              | 3            | 5        | 5                 | 3                                      |
| polycarbonate   | 30 days | 5                                              | 5            | 5        | 5                 | 5                                      |

Summarizing at the third stage of the study all the obtained results, they came to the conclusion about further work with polycarbonate [11, 12]. It turned out to be necessary to carry out additional elements of modular furniture parts in the form of soft pillows, mattresses. These elements will allow the use of children's furniture with great comfort. In the design process, the task was to design a multifunctional unit that was developed. On the basis of its combination, articles were made for storing accessories, seats, lying down and even the design as a table. It was decided to develop a multifunctional combinatorial modular furniture unit. Modular furniture is a set of individual furniture elements that are made in the same style, have interchangeability and wide possibilities of variant combinations, transformations, transformations and constructor [22, 27]. The modular principle allows you to create a wide range and variability of products from a limited number of standard blocks (Figures 3-4).

![Figure 3. Variant of the table.](image)

![Figure 4. Sunbed option.](image)

Any furniture unit is equipped with soft pillows, which can be removed if desired. The pillows are fastened with ties, which prevents them from slipping. If desired, the pillows can be removed - this will add furniture more constructive, as well as ease of perception of space. Thus, the presence of such multifunctional modular units allows you to organize the interior space of any interior, depending on its current functional purpose: game, sport, eating, etc. In this case, the material used is available and allows you to perform this furniture even at home. A comparative study of three non-traditional materials for the manufacture of furniture led to the conclusion that polycarbonate is the undisputed leader from which it is possible to make various multifunctional furniture.
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