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MODULAR FURNITURE IN INTERIOR

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ABSTRACT

The design model of Re-coding Homes is an attempt to shape living environments in relation to the needs of different types of users living in a specific place. Therefore in this research the concept of Mass Customization is handled in the scale of an all-inclusive living environment that change with their everyday life and activities requiring different interior layouts. Aims to present the modular and flexible furniture solutions created through the research project "Re-Coding Homes". Re-Coding Homes is based on creating interior design proposals by generating numerous furniture layouts with components especially designed to come together in different ways and configurations for standardized mass housing interiors.

Key note *: Design Model, Mass Customization, Modularity, Flexibility, Multi-functionality, Multi-parameter Layout.*

INTRODUCTION:-

The spatial variations embrace different interior furniture modules answering to different activity sets concerning the basic activities that take place in living units. Furniture solutions are an indispensible part of the design model as they complete the idea of spatial flexibility by allowing numerous configurations that support different activities. Project team worked on detailing the interior modules by conducting a hands-on study with continuous feedback from modeling and prototyping studies. In order to maintain the continuity between the phases of design, production, evaluation, redesign and reproduction, all studies were conducted in the ITU Model Lab. During prototyping, the final interior design variations generated by the

expert system began to be elaborated by the design team's interpretations and transformed into final products.

The research project Re-Coding Homes develops an automated design model that generates home environments according to parameters defined by user needs. All the interior components are part of the same modular system that allows different configurations at different alternatives. The definition of a three-dimensional grid creates the relation between the modules and the surrounding architectural shell maximizing effective use of space. The most significant contribution of the designers to the design model is the constitution of an expert system in relation to the raw data collected from the users and their living environment within the case study site.

Quality of life in living environments is greatly affected by furniture. Furniture supports all necessary activities taking place in our homes that are repeatedly subject to changes. On the other hand, the use of appropriate furniture, their relation to each other and to the existing architectural building envelope is an issue to be discussed. Aim of the study is to create alternative flexible solutions for mass housing units' interior spaces and to examine the issue with an interdisciplinary approach including interior architects, architects, and industrial designers. The structure plays a key role in managing complexity, in this manner, it can be said that modular design is an approach that supports flexibility on product basis. Within the scope of the study that is presented, the use of modular design principles in creating a design model has been effective in terms of obtaining product diversity that meets different uses and preventing complexity while creating various spatial combinations. Customized interior design, which is the subject of the study, is a complex and multi-criteria design problem. Multi criteria design problems run parallel processes and traditional design methods fail to solve such design problems. Today, computational generative design approaches have been used specifically for solving multi criteria design problems. Generative systems, with their dynamic processes and outputs, offer a new perspective on both conceptualizing design processes and working on the optimization designs. In this study, by means of Genetic Algorithms, an expert system that provides interior design alternatives according to different user types and uses has been developed.

Methodology

"People" represent the specific user, which gets involved in the design process by making his choices. "Actions" refers to the possible activities and behaviors of users. "Furnishings" represent the interior components to be placed in interiors and "Spaces" represent the existing environment for which the solutions are created. The expert system generates variations by placing "Furnishings" in "Spaces" considering the input about "People" and "Actions" related to every single space that is three dimensionally defined inside the system.

The main strength and originality of the research project Re-coding Homes is the use of an expert system in order to obtain the required flexibility in interiors. This expert system generates spatial configurations by the help of the design parameters defined by the design team. These parameters are mainly variables that differentiate the solutions according to the specific requirements of users related to the case study site. The main parameters are determined (Table1) and categorized as "People", "Actions", "Furnishings" and "Spaces".

Table 1. Main Parameters That Are Considered As Inputs for The Design Model and Their Influences

Data from field studies that can affect the design process	The fields that are affected by the specified data
Number of family members	Number of beds, single - double bed, arrangement of eating table, size of sitting area, size of storage, number of toilets
Presence of guests	Need for extra bed, configuration of eating table, bed storage, arrangement of sitting area
Activity space relationship	Sleeping, sitting, eating, breakfast, accepting guests, playing, cooking, working
Main problems /complaints	Dark rooms, insufficient storage, small kitchen and toilet.
Colors and patterns	Furniture design
Socio-economic situation	Decision of materials and techniques

The expert system worked with Genetic Algorithms which means designs were worked to be evolved within computer environment according to meet the fitness functions determined by the design team (Figure 1).These fitness functions defined the relationship between Furnishings and interior envelopes of Spaces in order to avoid meaningless and inappropriate solutions. In this way users could make their decisions in terms of the features of their family and their specific needs. On the other hand, designers decided on the rules of design by considering the data from field research while the computer processed all these raw data to generate successful design alternatives. The expert system also provided the connection between the design model and the user interface that presented the solutions to users according to the answers they give to the online questionnaire. The main objective of the web interface is to provide the user with various interior layout alternatives and modular furniture that meet their needs. The interface, which includes representation and information on the different variations offered by the design model, is considered to be a factor that will significantly increase the applicability of the project. It aims to present all the outputs of the design phase in a manner that the user will be able to comprehend.

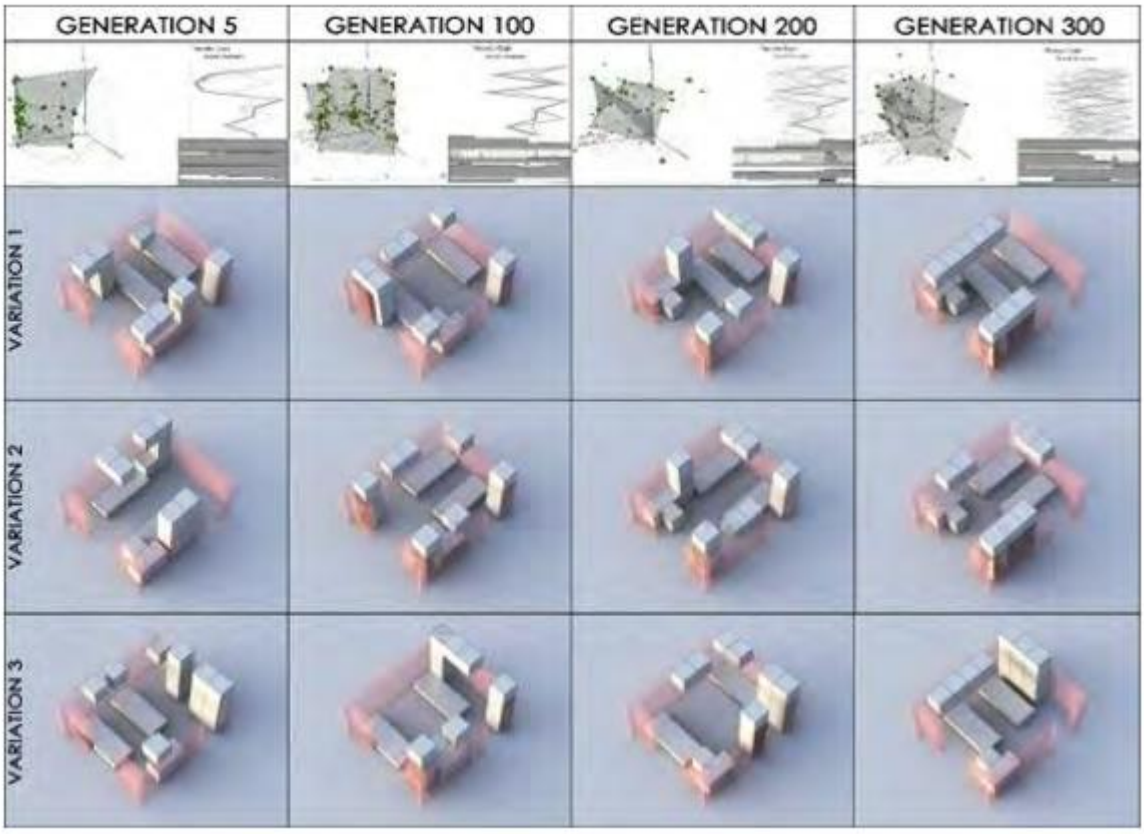

Figure 1. A matrix created by selecting three alternatives from the designs evolving 5,100, 200 and 300 times respectively for one of the rooms (Sagler Onay et al., 2017)

All components need to be modular or they need to fit in a modular grid. In terms of modular coordination, 60x60 and 30x30 cm modules are considered to be used in the plan layout, and a 30 cm grid to be dominant within anthropometric requirements in the sectional layout. \

In the plan layout, living and storage areas are differentiated. While areas close to windows with more natural light were reserved for multipurpose living spaces, areas with longer and continuous walls far from windows were reserved for storage (Figure2).

In rooms where more flexibility is needed, the modules need to be multifunctional fulfilling all of the main activities that take place in the room. For example, the living area within the living room was organized to accommodate activities such as sitting, eating, entertaining (neighbors and overnight guests), chatting, watching TV etc. Therefore the modules that meet these activities were considered within a setup that could be used in different forms depending on the increase in the number of users.

Similarly, the modules that meet the main activities in bedrooms such as sleeping, resting, sitting, playing, watching TV, hosting overnight guest were setup so as to meet different needs by being brought together in different ways by the users themselves when needed.

Figure 2 shows the decisions about fixed and mobile modules. Mobile module zones are identified with dashed line while fixed modules are shown with continuous line. Grey modules represent the storage zones that can be higher when needed.

Especially fixed modules will be attached to walls in order to leave the central areas as flexible as possible for changing needs and furniture layouts created with mobile modules.

All the design principles listed above are defined to the expert system as design constrains in order to create rational solution sets. Other than these, many other rules are defined in order to place furnishings in rooms. The genetic algorithm is launched with these rules or fitness functions to create design alternatives by simultaneously considering each fitness function during the installation of furnishings.

Figure 2. The modular layout showing mobile and fixed module zones and decisions about

Design Process

All modules and furniture are detailed in a parallel process to expert system studies. They all fit in the 3D grid of 30 cm x 30 cm x 30 cm. The furnishings, which were represented in simple cubic geometry in the previous stage, meet the actual space in real furnishings. All the modules except some of the modules forming the kitchen counter can come together in different configurations. Movable modules are handled in 2 main groups. The first group rests on the floor and they are raised from the pavement 12 centimeters with metal legs. The second group is made up of modules that can be placed on modules that rest on the floor.

These modules can be secured on other modules by the help of metal frames that fit in grooves cut in wooden plates forming the modules. The frames prevent the modules from sliding over each other and they can be easily assembled and dismantled by users themselves. In this way users can change the places and configurations of modules according to the activities that will take place in their living environments.

The modular units can be grouped in categories according to the activity sets they are designed for. In this sense the modules can be grouped as follows:

- Multifunctional seating modules x Multifunctional storage modules (19 modules)
- Multifunctional divisible bed/seating modules (3 modules)
- Chair and taboret solutions
- Extendable table modules

Figure 3 shows the list of modular furniture solutions developed for each space and activity. Flexibility in each space where multi-use is needed has been discussed within both the general layout and the modular-furniture scales. The layout and furnishings vary according to the family types, and the alternatives gathered from the evolved designs of the expert system have become a basis in this sense. For spaces that require more flexibility, the use of multifunctional solutions was indispensable. For example for the living room the sitting units were designed to be used as pouf, coffee table, sofa and bed by only changing the places and configurations of modules and their components. Correspondingly, for the bedrooms a multifunctional divisible bed system that could also be used as sofa for sitting was developed. The same bed modules could be also adjusted as bunk bed in case of increasing users.

	spaces	activities	solutions
Spaces that require multiple use solutions	Living Room	sitting, watching TV sleeping (for guests), playing, storing	Multifunctional seating modules The flexible use of the same unit as coffee table, pouf, sofa and bed.
		eating, working platform, counter	Extendable table modules
	Room 1 Big Bedroom	sleeping, sitting, watching TV, playing, working, storing	Multifunctional divisible bed/sitting modules Integrated working table, TV unit and storage module
	Room 2 Small Bedroom	sleeping, sitting, watching TV, playing, working, storing	Multifunctional divisible bed/sitting modules Integrated working table, TV unit and storage module
	Balcony	sitting, eating, drying, storage	Extendable table modules Multifunctional hangable storage, drying, planting modules
Spaces that have specific uses	Kitchen	cooking, storing, eating	Fixed counter and storage modules Extendable table modules Multifunctional storage modules
	Bathroom	personal care	Multifunctional storage modules
	Hall	storage	Multifunctional storage modules

Figure3. List of modular furniture solutions developed for each space and activity (Saglar

Multifunctional Seating Modules

Seating modules can be arranged in different combinations by the help of metal frames with dimensions of 46 cm x10 cm x 2.4 cm. These frames are designed to combine modules in order to maintain sitting and sleeping surfaces according the number of users. These surfaces can be both situated beside the walls or in the middle of the living room. As the place and configuration of seating modules can be interpreted in many different ways they are designed to be as light as possible by emptying unnecessary parts like the back, front and partially the bottom plate surfaces. Likely the connections of modules are maintained by light metal frames that fit into narrow grooves on wooden plate surfaces. In this way modules can be simply fastened to each other and the layout of the living room can be rearranged in minutes by the users themselves.

The seating module is designed to be adjusted to different uses as it is intended to be used mostly in the living room where different activities need to be fulfilled. The module fits the first horizontal grid level of 30 centimeters in terms of modular coordination and it is raised from the floor with metal frame legs. The front and the backsides of the seating module are left open in order to place the seating cushion and use the body of the module as a coffee table.

Multifunctional Storage Modules

Modules that can be hung on the walls are especially designed for small balconies that are used for many different activities such as planting, drying clothes, storage etc. These solutions are very important in order to maintain the required flexibility for balconies, which are evaluated as one of the most precious parts of homes by most of the users in mass housing units. In this sense the modules are designed to be hung on wooden rails that can be fixed on the walls according to the modular grid. Hang able modules are differentiated as laundry module, storage module (with transparent cover) and plant module. While these units are resolved on wall surfaces, it becomes possible to use balconies for other purposes like sitting, eating, working etc. If needed these modules can also be used on interior walls. Moreover additional table modules and taburets that are also designed to be used in small spaces like balconies, can be hung on the same rail system.

Storage modules are the modules that require more variety because of the differentiation in storage needs and the dimensional differences between various storage areas within home interiors. All modules fit in the 3D modular grid. Among 19 different types of storage modules, 9 can be directly placed on the floor, 3 can be placed on other modules and 6 can be hang to the rails on the walls. Modules resting on the floor are differentiated as chiffonier, shoe cupboard, coffee table, drawer filling cabinet, rug cabinet and show cabinet. These modules are all raised from the floor with metal frames and modules that have the same height can be fastened to each other with horizontal metal frames. Modules that can be placed over other modules are single drawer module, box module with transparent front and opaque front. These modules are smaller and lighter in order to allow users to change their configurations according to their changing storage needs. They are all fastened to each other by the help of a single metal frame that fits in the grooves carved on the top plates of modules. This simple connection principle makes it possible to make short-term changes regarding the configuration of storage modules. The grooves carved on the modules also create a geometric pattern and underline the modular structure of the system.

Multifunctional Bed/Seating Modules

The main concept of bed modules is developed to fulfils two activities with changing needs. In this sense the combination of one narrow and one wide module simply forms a platform of 90x210 cm raised 30 centimeters from the ground. This platform becomes a bed by placing a mattress of 15 centimeters with 32 density over it. The same modules can be used as a sofa and a coffee table when separated from each other. The mattress part remaining on the narrow module can be detached from the part remaining on the wide module and it can be placed inside the narrow module. In this case the narrow module becomes a coffee table beside the sofa module. In the same way the double bed can be transformed into two sofas and one coffee table when needed. These two different principles of combination simply allow using the same room both for sitting and sleeping. Especially in the context of Istanbul and mass housing units, users usually need two rooms to sit for men and for women/kids. The

bunk bed also allows the room to be used for many other purposes by emptying the floor level. The space under the raised bed platform can be used to place another single bed, storage units, a working table, a sofa or can be simply left empty like playground etc. The metal structure holding the bed modules serves as both ladder and as rails to hang small storage modules.

3 different types of bed configurations are developed by using only 2 different modules and a steel structure. This steel structure serves to obtain an upper bed level in order to maintain spatial flexibility and increase effective space in rooms. The single and double beds are formed by the combination of narrow and wide bed modules using metal frames. Bunk beds are obtained by the combination of one narrow, one wide bed module fastened to the steel structure, which holds the modules at the level of 180 cm in the modular grid. The standard wide bed modules are designed to embrace three wide and one narrow drawers that can be used to store clothes, bedding, quilt c

Table Modules

The integrated working table, TV unit and storage module is designed to be used in rooms. There are two types of working tables, which differ in depth. The narrow one of 30 centimeters is intended to be used in smaller rooms especially for children. The wide one of 60 centimeters is developed for the master bedroom. over etc.

Table modules are differentiated according to their purpose. Those that are designed to be used for eating, counter etc. are intended to be extendable. Regarding the solution used in the living room, the metal structure holding the middle part of the table can be extended to hold additional table plates of 60x60 cm from both sides. These additional table plates can be hung on the wooden rails on the wall surfaces. On the other hand the balcony solution is designed to be extended by adding 30x30 cm table plates to a plate of 90x20 cm fixed on the wall. Again these additional table plates can be hung on wooden rails. The table and taboret solutions are also developed to support the flexible use of space and they can all be folded and hung on rails.

Model And Prototype Studies

The 1/10 model of the whole apartment unit was an important tool during the design process (Figure 4). The main purpose of physical model was to discuss the concept of modularity in a holistic way regarding the interiors. The walls were made of transparent Plexiglass and the modular grid was engraved on plexiglass surfaces in order to discuss the relations between modules and interior envelopes. Led strips were fixed within the walls to underline the modular grid. The model was also intended to be used in order to discuss the results of the study and exhibit the solutions.

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Figure 4. 1/10 model of the whole apartment unit in TOKI Basibuyuk Housing (Saglar Onay,

Physical modeling studies also aimed to create a design language that embraces all of the modular solutions (Figure 5). The modular grid, material, connection frames, grooves carved on wooden surfaces were evaluated as factors that help to maintain the common design language. All storage modules were designed to be raised from the floor with the same metal legs and they were all designed to be connected with the same metal frames. All the modules were developed to fit in the modular grid. This principle was vital to maintain maximum flexibility allowing the combination of different modules. Figure 6 shows a detailed example showing different configurations of seating modules.

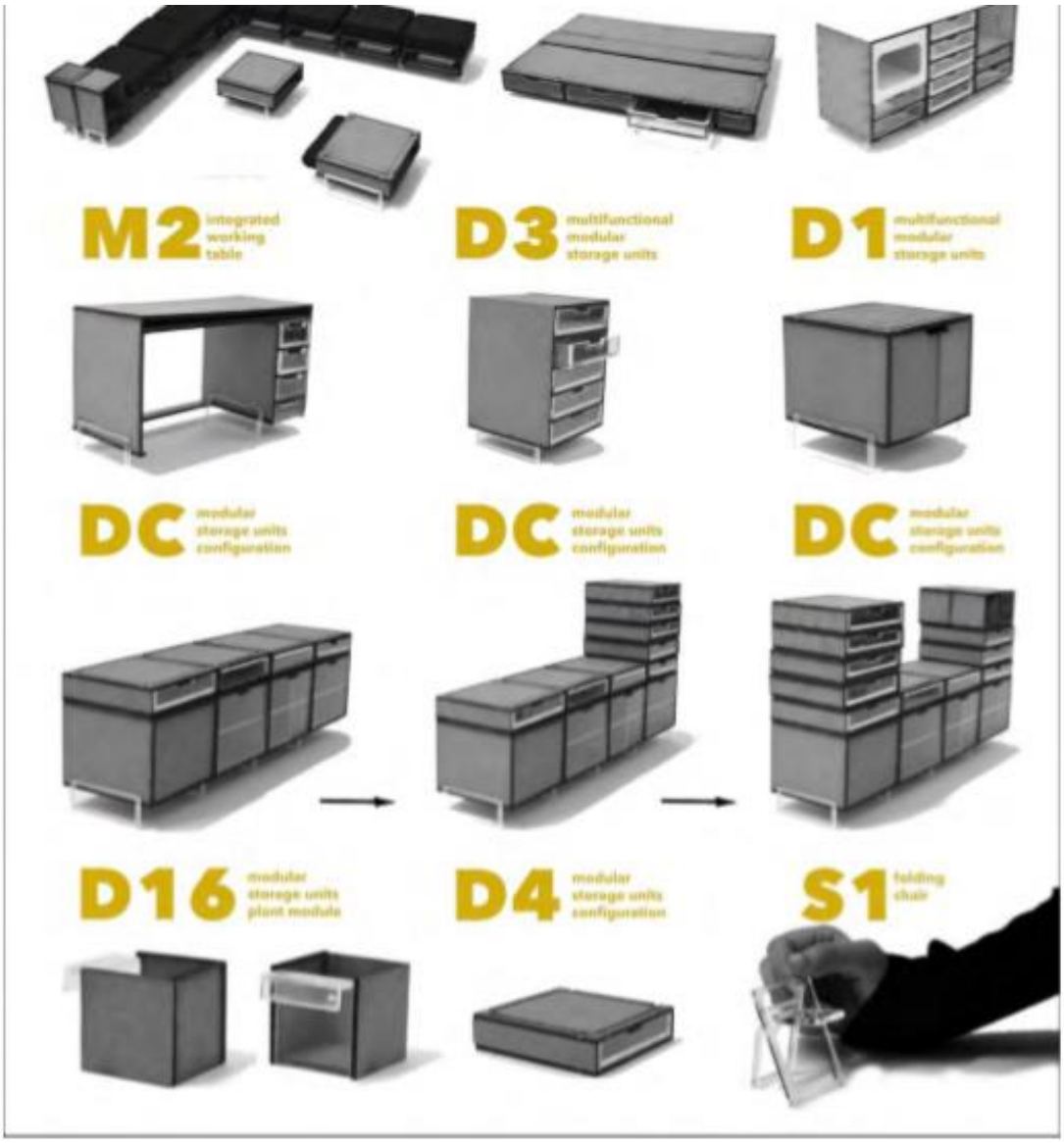

Figure 5. Common design language of modular furniture solutions and 1/10 models (Sag

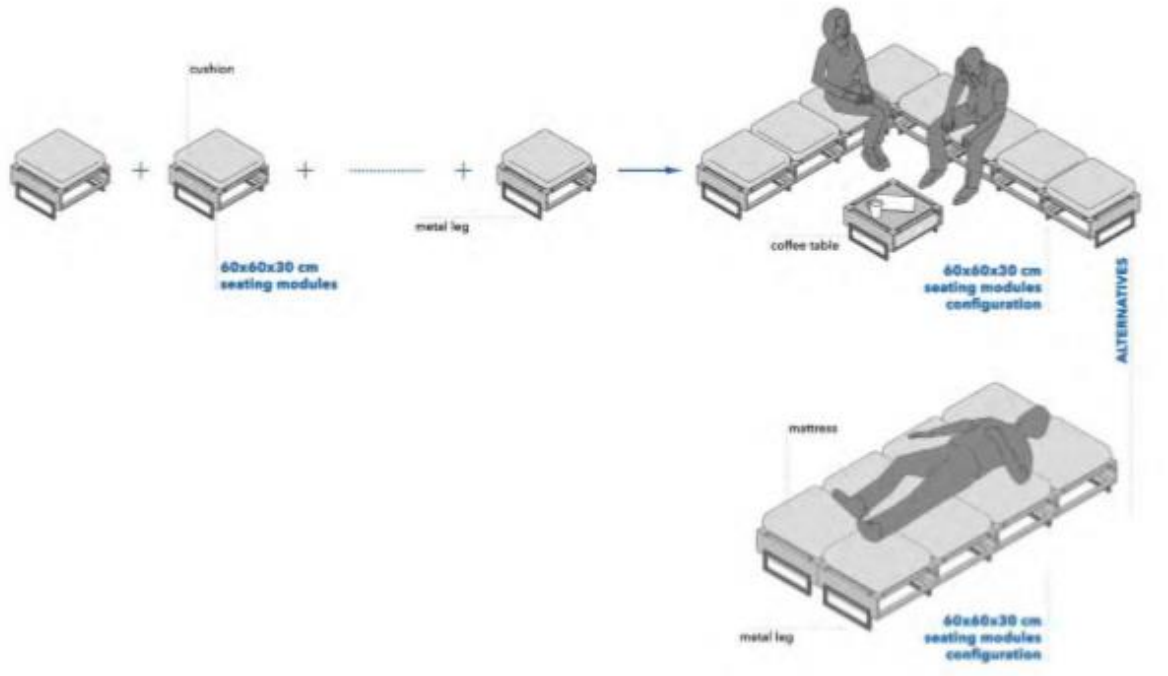

Figure 6. Example showing different configurations of the seating modules (TUBITAK

The prototype studies mostly focused on material decisions and connection details. As the modules are intended to be assembled by the users themselves, materials needed to be as light as possible. In this sense birch plywood was chosen as an appropriate material as it is light and it can be used without additional surface treatment. MDF was chosen as an alternative material in order to reduce costs and create more economic solutions. The dovetail joint was used for the connection of MDF/ plywood plates (Figure 7).

Conclusions

The modular interior components designed for the project Re-coding Homes represent a product family that can come together in many different ways as a result of the modular and flexible design approach. This approach creates variety both for the spatial variations

generated by the expert system and temporary changes made by the users themselves. In this sense, the spatial variations are not limited with the ones created by the expert system and presented by the user interface. The multi-functionality of modules allows many other temporary variations. Therefore, in this research, the concept of Mass customization is handled in the scale of an all-inclusive living environment that changes with their everyday life and activities requiring different interior layouts. Thus, living environments live together with inhabitants.

The design model of Re-coding Homes is an attempt to shape living environments in relation to the needs of specific users living in a specific place. Therefore, information from the existing architectural envelope and users is the most important input for the model. On the other hand, the most significant contribution of the designers is the constitution of the expert system in relation to this raw data. The designers define a hierarchical order between all this data and formulate the fitness functions that will guide the computer to generate spatial variations. Furniture solutions are an indispensible part of the design model as they complete the idea of spatial flexibility by allowing numerous configurations that support different activities. In this sense the model does not have applicability without the understanding of configurable modules.

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