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ASSESSING RELEVANT QUALITY ATTRIBUTES FOR DESIGNING AN ERGONOMIC DORM ROOM WITHIN THE ROMANIAN CONTEXT

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Abstract: *The functionality of a dorm room and the productivity of the student work depends on the space arrangement considerations, yet the needs and desires of its user are seldom considered. Standard dorm-rooms house students with different workloads and schedules, space requirements and psychological needs. The present paper aims to design as efficiently as possible an ergonomic dorm room for Romanian students. For this purpose, the Kano methodology and the Quality Function Deployment (QFD) tool are used to discuss and determine the most relevant quality attributes.*
Key words: *student workspace, dorm-room ergonomics, Kano, Quality Function Deployment, Voice of the Customer.*

1. INTRODUCTION

Mostly aimed at adapting the work environment to the employee, ergonomics' well-established goal is to eliminate discomfort, risk of injury and increase productivity. The ergonomics of each individual piece of furniture can be easily measured and improved based on anthropometric and physiologic particularities but psychological ones are often disregarded. Mixed use, multifunctional environments in which work is an ill-fitting yet indisputable component are similarly overlooked. Thus, the authors chose to focus on student dorm-rooms as, despite technically not being employees, students are required to carry out a considerable amount of work and produce a wide variety of end products based on their specialty.

The authors have chosen an ergonomic approach because, as Alam and Khan [1] state, "in the case of built environment and space design, ergonomics is the basic unit for initiating the design process". The functionality of a dorm room and the productivity of the student work depends on the space arrangement considerations. But space arrangement needs to correspond to the needs and desires of its users, in our case, students. Standard dorm-rooms house students with different workloads and schedules, space requirements, psychological needs. Therefore, their voice must be heard and implemented in the design from the beginning. University managers cannot start the design process without having a clear image of the attributes which will differentiate and create added value for their future students.

In the light of these arguments, the present paper aims to design as efficiently as possible an ergonomic dorm room for Romanian students. For this purpose, the Kano methodology and the Quality Function Deployment (QFD) tool are used to discuss and determine the most relevant quality attributes we need to take into consideration from the design stage of such a room.

2. ASSESSING THE VOICE OF THE CUSTOMER FOR AN ERGONOMIC WORKPLACE. A LITERATURE REVIEW

2.1 The Ergonomics of Student Workplaces

A particularity of student workplaces is that they are only partially location bound, as they can be found on a campus, dorm and dorm-room scale.

Irrespective of typology [2], be it a separate urban entity on the city outskirts as ETH Zurich's Science city, an integral part of a city as Timisoara's "Complex Studentesc", or the nomadic Red Bull Music Academy, all campuses have libraries, laboratories, studios, offices, study halls, as designated student workplaces, usually characterized by large dimensions and specialized equipment.

At the dorm scale, common areas are designated for work, such as study halls, or to relieve dorm rooms of some of their functions, such as a communal kitchen, to make more room for work. Despite their deficiencies, from an equipment, ergonomic and psychologic point of view, the author chose not to focus their study on dorm level workplaces as the smallest scale one, the ones inside individual rooms, are the most impactful.

Despite differences between various dorm room typologies the designated space per student is similar. A focus group carried out with several architects clarified the dorm rooms' main functions, sleeping, relaxing socializing, eating, studying, storage and sanitation, and their deficiencies.

The workspace was proven especially inadequate. The 50x50cm fixed desk with a non-adjustable chair and insufficient room, does not promote good posture, is ill-suited for specialized activities and lacks any degree of intimacy or separation from the rest of the room. The authors chose to conduct an ergonomic analysis on the entire room due to its multifunctional character and limited space which entails an overlapping of activities in all available spaces.

According to Lobdell, [3] the configuration of study areas is detrimental for engagement, focus and data retention. Study areas must be separated from all other, especially from ones dedicated to sleeping, to increase productivity on the one hand and allow for disconnection, relaxation and sleep, on the other. Spaces can be multifunctional but separation and distinct character are crucial.

To establish the distinct functionalities and the options to modify them a time-based analysis was conducted for a live-work environment (Figure 1).

O average 33.3% of a typical 24h is spent in bed, an equal amount sitting at a table/desk to work or eat, 16.5% relaxing on a couch and only 14.5% standing. The space needed for each activity was mapped to identify unused areas in a 3D space configuration (Figure 2).

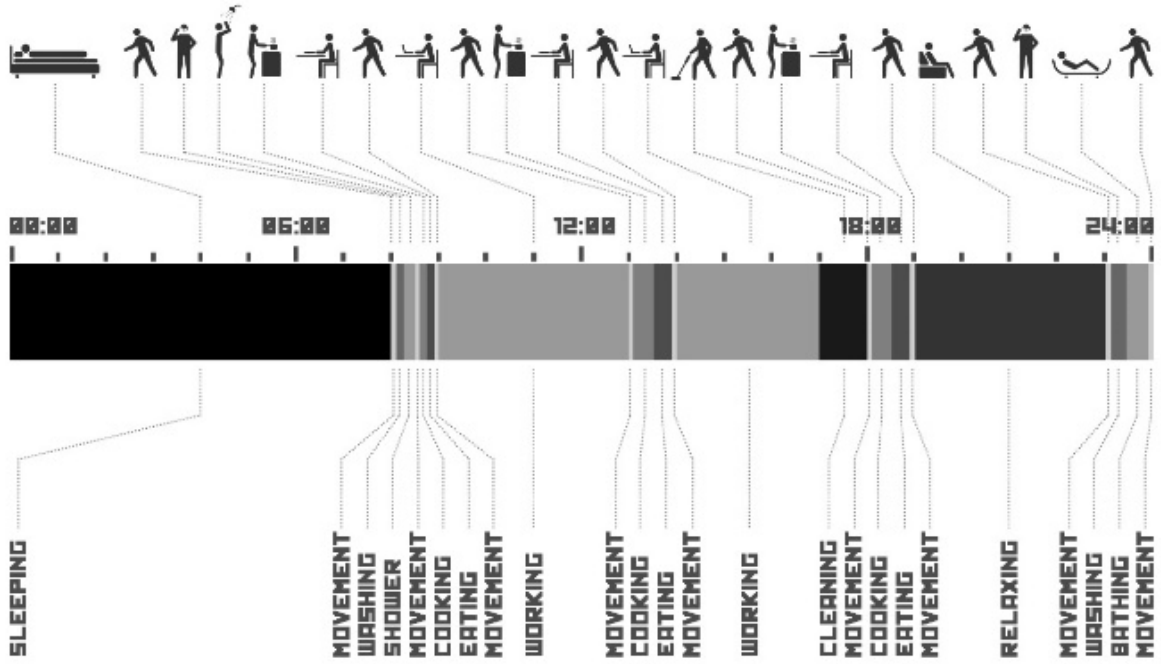

Fig. 1. Time-based analysis for a live-work environment

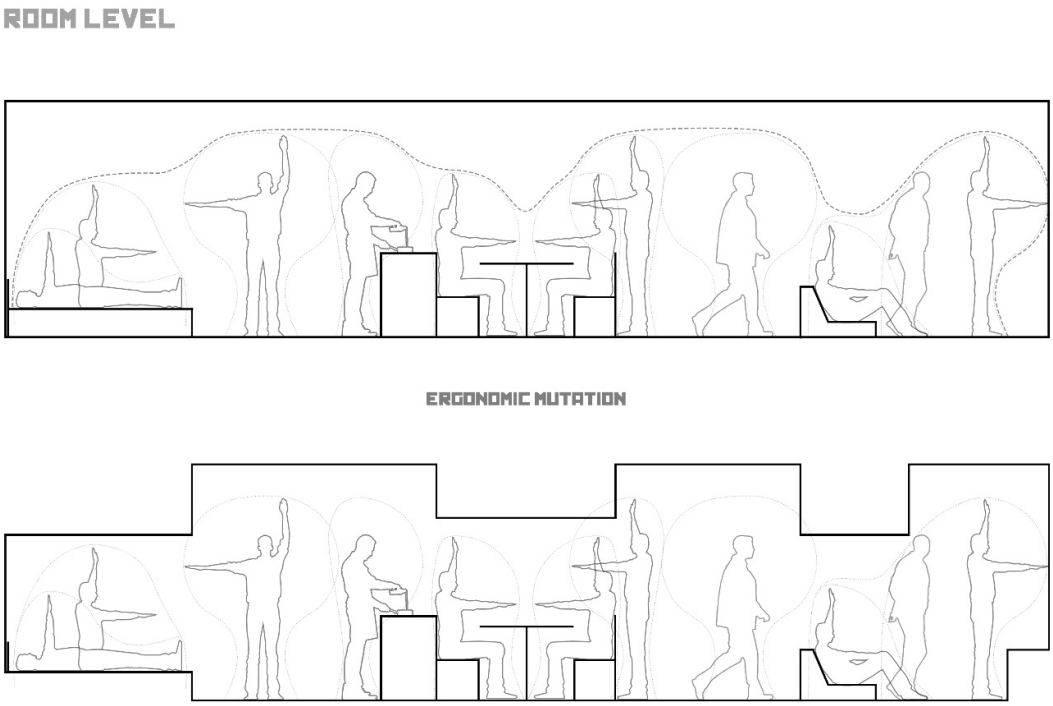

Fig. 2. Space mapping by type of activity

Several architectural principles were employed to resolve the identified issues, enhanced multifunctionality through furniture flexibility (some pieces can transform into others), enhanced multifunctionality by integrating several functionalities in a piece of furniture, area separation, furniture adjustability for different body types, sizes and activities and use of all available space.

2.2 The Kano method and the QFD approach for assessing the Voice of the Customer

The theory of attractive quality and especially the Kano model have been developed and overly discussed through the last two decades due to the fact that today more than ever companies and organizations worldwide have changed their focus from the limited viewpoint of their own internal professionals towards the public, their clients and users. The voice of the customer is an important asset and it is incorporated in detail for customer delight and loyalty purposes.

The Kano model [4] addressed for the first time the non-linear relationship between quality attribute performance and customer satisfaction [5]. Thus, it has been demonstrated that not all features of a product/service/experience have the same impact on customer satisfaction and that this satisfaction does not increase linearly with the improvement of a characteristic. The Kano methodology aims to analyse user demands and provide the most relevant requirements in the design stage of an offer [6]. For this purpose, the Kano questionnaire is built. For each quality attribute (product/service feature/characteristic) we have two pair of questions (a functional and dysfunctional question). First, we need to ask the potential customer how he/she feels if a certain feature is provided and secondly, the customer must answer how he/she feels if the feature is not provided. The answers are standardized for all questions and limited to five possibilities: “I like it”. “it has to be that way”, “I am neutral”, “I can live with it that way” and “I do not like it”. The two paired answers are analysed based on the Kano evaluation table and the respective quality attribute (design feature) is classified into one of the six available Kano categories: must-be, one-dimensional, attractive, indifferent, questionable, and reverse.

If the analysed quality attribute finds itself in the *must-be* (M) category, this emphasizes the

fact that the customer considers it as an inherent basic feature and does not think it is appropriate to even mention it. If the designers improve such a feature, this will not trigger an increased customer satisfaction but if they exclude it, the customer will be extremely dissatisfied. When we have a *one-dimensional* (O) category for a specific feature, this means that the customer expects it to be implemented into the offer and his or her satisfaction will increase linearly with its improvement/provided added value. An *attractive* (A) feature on the other hand will surprise and delight the customer if present but will not have a negative effect if missing because the customer does not expect the quality attribute at all. An *indifferent* (I) category means that the customer will not be satisfied or dissatisfied by the presence or absence of the feature. The *questionable* (Q) category does not happen very often, and it means that the respondent was not careful with the answer or that the question was not clear enough. If we have a high number of questionable categories answers the question need further analysis or has to be rephrased. The last *reverse* (R) category expresses a backwards influence on customer satisfaction, as argued by Potra et al. [7].

When a feature has two very closed category answers, Matzler et al.'s [8] evaluation rule M>O>A>I can be applied. On the other hand, Nilsson-Witell and Fundin [9] imply that an attribute that has two strong categories is probably changing from one category to another due to quality attribute dynamics [4]. These arguments need to be considered for a relevant assessment of quality attributes.

But for a more complex analysis we can calculate Berger et al.'s [10] average (better and worse) indicators. The positive better numbers give the relative value of meeting customer requirements (satisfaction can be increased if attractive and one-dimensional elements are provided) named customer satisfaction coefficient - SC and the negative worse numbers indicate the relative cost of not meeting that requirement (customer satisfaction can be decreased if one-dimensional and must-be elements are not included) named customer dissatisfaction coefficient – DC. Matzler et al. [8] together with Zhu et al [11] have extended the two coefficients to: satisfaction index (SI) for the positive CS and dissatisfaction index (DI) for the negative CS.

The formula for SI and DI can be seen in the following:

$$SI = (A + O) / (A + O + M + I) \quad (1)$$

$$DI = (-1) (O + M) / (A + O + M + I) \quad (2)$$

where SI represents the satisfaction index and DI the dissatisfaction index, A stands for attractive, O for one-dimensional, M for must-be and I for indifferent category.

As expressed by several scholars and argued by Potra et al. [7], SI ranges from zero to one. Its influence is considered as very high when the index approaches the value of one and very low if it approaches the value of zero. On the other hand, DI ranges from zero to minus one due to the fact that in equation (2) we add minus one to the computed result to emphasize the negative influence on customer satisfaction if the feature is not incorporated into the product or service. Its negative influence is considered as very high when the index approaches the value of minus one and very low if it approaches the value of zero.

Park et al. [12] summed the absolute value of SI and DI and determined the average satisfaction coefficient (ASC), an indicator of a total performance score for the analyzed quality attributes. The formula for ASC defined by Park et al. [12] ca be seen in equation (3).

$$ASC = (|SI| + |DI|) / 2 \quad (3)$$

By determining the Kano category and computing the SI, DI and ASC values, each feature can be further discussed and better understood from the customer point of view. For a complete assessment, the Kano method can be combined with the Quality Function Deployment (QFD) tool because as argued by Witell, Löfgren and Dahlgaard [13], these two are the most common pair of methods used together. Shen, Tan and Xie [14] have been one of the first papers that adjusted the Kano attribute classification and thus importance weights of customer needs with the House of Quality (HoQ), QFD's first matrix which organizes: customer requirements (CRs), design or quality requirements (DRs), their relationship and the correlations and dependencies of DRs.

3. METHODOLOGY

The present research envisages to assess as efficient as possible the ergonomic design requirements for a dorm room in the Romanian context. These requirements have been determined based on a literature review and two focus groups (one with architecture students for the VOC and one with architects and engineers from Politehnica University Timisoara).

In Table 1 we can see the 10 possible quality attributes corresponding to the VOC.

For the 10 already established customer requirements a Kano questionnaire has been built. Before applying the questionnaire, we have established an optimal proportional sample size for the stratified survey. It is considered that the general population of the university Bachelor students N= 15.000, with ages ranging between 18-26 years, both males an females are divided into nine faculties in the analysed state. Based on the amount of error and uncertainty we can tolerate (5%) and a confidence level of 88%, the sample size n is established. The result with the above-mentioned characteristics represents a sample size of n=235 individual valid responses.

The sample layers are delineated based on the faculties the respondents are enrolled in (Table 2).

Table 1

Customer requirements regarding an ergonomic dorm room

	Customer requirements	Requirement description
1	Space saving furniture, bed/desk	Large work area available on demand, by folding the unused bed
2	Space saving furniture, bed/couch	Increased area for socializing using a sofa bed
3	Intimacy for the bed	Flexible, light enclosure to separate one's sleeping area from roommates
4	Storage space under bed	Easily accessible storage space under the bed
5	Separate areas for work and sleep	Private area dedicated to focused work/study
6	Adjustable desk	Desk suited for various work positions, activities and body types
7	Folding desk	Work area available only for occasional use
8	Wipeable surface to write or draw	Large surface to write/draw
9	Surface to pin notes and photos	Large surface to decorate without damaging the walls
10	Increased storage space	Structured storage areas in all available spaces

Table 2

Sample layers for the respondents of the Kano questionnaire

	Faculty name	No. of resp.	%
1	Architecture and City Planning	70	29.8%
2	Management in Production and Transportation	60	25,5%
3	Automation and Computing	30	12.8%
4	Mechanical Engineering	28	11.9%
5	Electronics, Telecommunications, and Information Technologies	18	7.7%
6	Civil Engineering	11	4.7%
7	Industrial Chemistry and Environmental Engineering	9	3.8%
8	Electrical and Power Engineering	6	2.6%
9	Communication Sciences	3	1.3%
	Total	235	100%

Table 3

The CRs and DRs of the dorm room

	Customer requirements (CRs)	Design requirements (DRs)
1	Space saving furniture, bed/desk	Bed transformed into desk
2	Space saving furniture, bed/couch	Bed transformed into couch
3	Intimacy for the bed	Moving panel or textile to isolate bed
4	Storage space under bed	Bed frame with large integrated drawers
5	Separate areas for work and sleep	Separation panel
6	Adjustable desk	Height and inclination adjustable desk
7	Folding desk	Hinged wooden panel
8	Wipe able surface to write or draw	Whiteboard paint as wall finishing
9	Surface to pin notes and photos	Cork finish on the wall
10	Increased storage space	Storage shelves above bed/desk

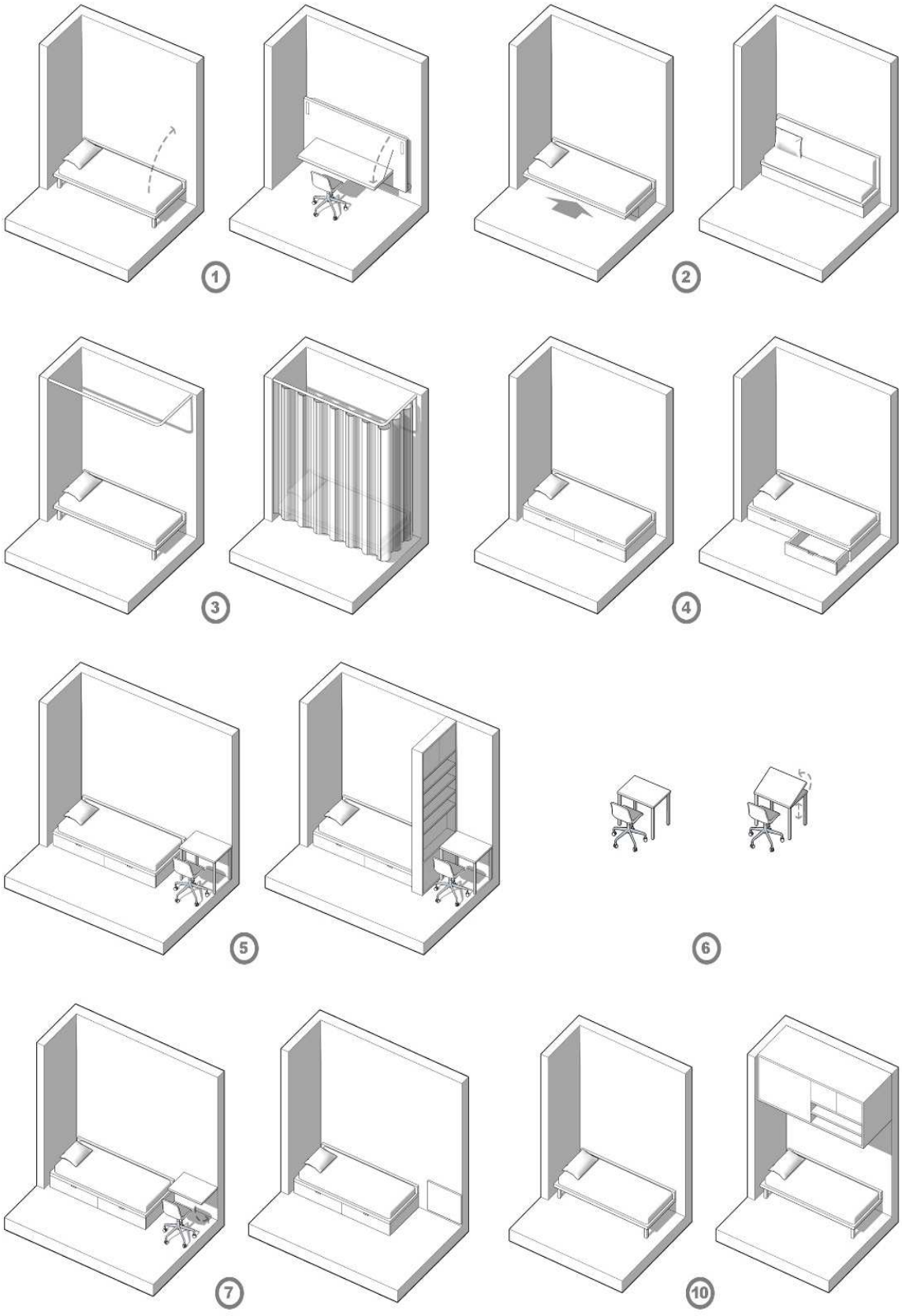

Fig. 3. Design requirements of the dorm room

Based on the questionnaire responses the Kano categories have been determined and the SI, DI and ASC coefficients have been computed. The ASC values have been introduced in the HoQ matrix and the correlated design requirements have been stated (Table 3 and Figure 3).

In the roof top of the HoQ the existing correlations between quality characteristics (positive, negative or no correlation) are explored. These correlations are underlying the way in which design requirements are supporting each other, can be developed in parallel or determine conflicts. The importance of the design requirements is evaluated based on the relationship matrix between CRs and DRs, analysing the way in which a quality characteristic will support and lead towards the satisfaction of a customer request [7]. In the end, in the lowest part of the HoQ the difficulty of the 10 design requirements is evaluated and stated from 1 to 10 (10 being very difficult to implement). Below it we can encounter the maximum value of the relationship analysis for each design requirements. This value is computed by multiplying the importance (ASC indicator) of the customer requirements with the result of the relationship analysis (Strong relationship -9, moderate relationship – 3, weak relationship – 1). After taking into consideration the difficulty and the relationship value, a weight/importance value is delineated for the 10 design requirements.

4. RESULTS AND COMMENTS

In Table 4 the results of the Kano questionnaire together with the computations of the SI, DI and ASC indicators are presented.

From Table 4 we can see that three customer requirements (quality attributes) are clearly one-dimensional in nature, namely: the intimacy for the dorm room bed, the storage space under the bed and the increased storage space in the room. Thus, students need and explicitly desire intimacy and storage in their rooms.

The other seven requirements have been categorized as attractive. But further analysis is necessary because for example the space saving furniture bed/desk has a high number of reverse answers or the space saving furniture bed/couch and folding desk have also a high number of one-dimensional answers.

In these cases, the attractive quality needs to be discussed together with the second most answered category. In the case of quality attribute 2 and 7, as implied by Nilsson-Witell and Fundin [9], the attractive features are changing into one-dimensional characteristics due to attribute dynamics.

Their ASC values are very high as for the other one-dimensional features. Therefore, they need to be taken into consideration when designing the dorm room.

For the first quality attribute with many reverse answers, we can probably assess the fact that students would rather like a normal bed and not the proposed variant. This is the reason also the indifferent answers are very high in number.

In the case of related (close together) attributes like the desk options 6 and 7 or the surface options 8 and 9 where just a variant can be implemented, we need a further analysis tool, namely we need to develop the HoQ in the scope of transforming the VOC into design requirements. In Figure 1 the HoQ is presented.

From the roof top of the HoQ the negative correlations between the design requirements are observed: the implementation of 1 hinders the implementation of 2, 4, 5 and 6 or the implementation of 6 hinders the option 7, the same is in the case of design requirements 8 and 9. In this situation the problematic design requirements need further attention.

The relationship matrix shows us how many requirements are correlated or have a certain relation with one another. The value of these relationships is computed in the Max Relationship Value columns for each DR.

The implementation difficulty is also considered for a thorough hierarchy of the design requirements. In the end the most important DR is bed transformed into couch requirement due to the fact that it is an attractive transforming into one-dimensional Kano category requirement for the customer with a high ASC value, it has no negative correlations with the majority of DRs, is easy to implement and has the highest value from the relationship matrix.

Table 4

Results of the Kano questionnaire with SI, DI and ASC

Nr crt	Quality Attribute	A	O	M	I	R	Q	Total	Kano category	SI	DI	ASC
1	Space saving furniture, bed/desk	82	16	3	56	64	14	235	A-R	0,62	-0,12	0,37
2	Space saving furniture, bed/couch	105	49	20	28	21	12	235	A-O	0,76	-0,34	0,55
3	Intimacy for the bed	59	75	30	54	15	2	235	O	0,61	-0,48	0,54
4	Storage space under bed	50	113	46	19	2	5	235	O	0,71	-0,69	0,7
5	Separate areas for work and sleep	71	65	9	64	21	5	235	A/O/I	0,65	-0,35	0,5
6	Adjustable desk	93	48	13	61	8	12	235	A	0,65	-0,28	0,46
7	Folding desk	84	69	16	55	6	5	235	A-O	0,68	-0,37	0,52
8	Wipe able surface to write or draw	115	46	7	44	13	8	235	A	0,75	-0,24	0,49
9	Surface to pin notes and photos	93	44	10	63	11	14	235	A	0,65	-0,25	0,45
10	Increased storage space	49	87	26	50	10	11	235	O	0,63	-0,52	0,57

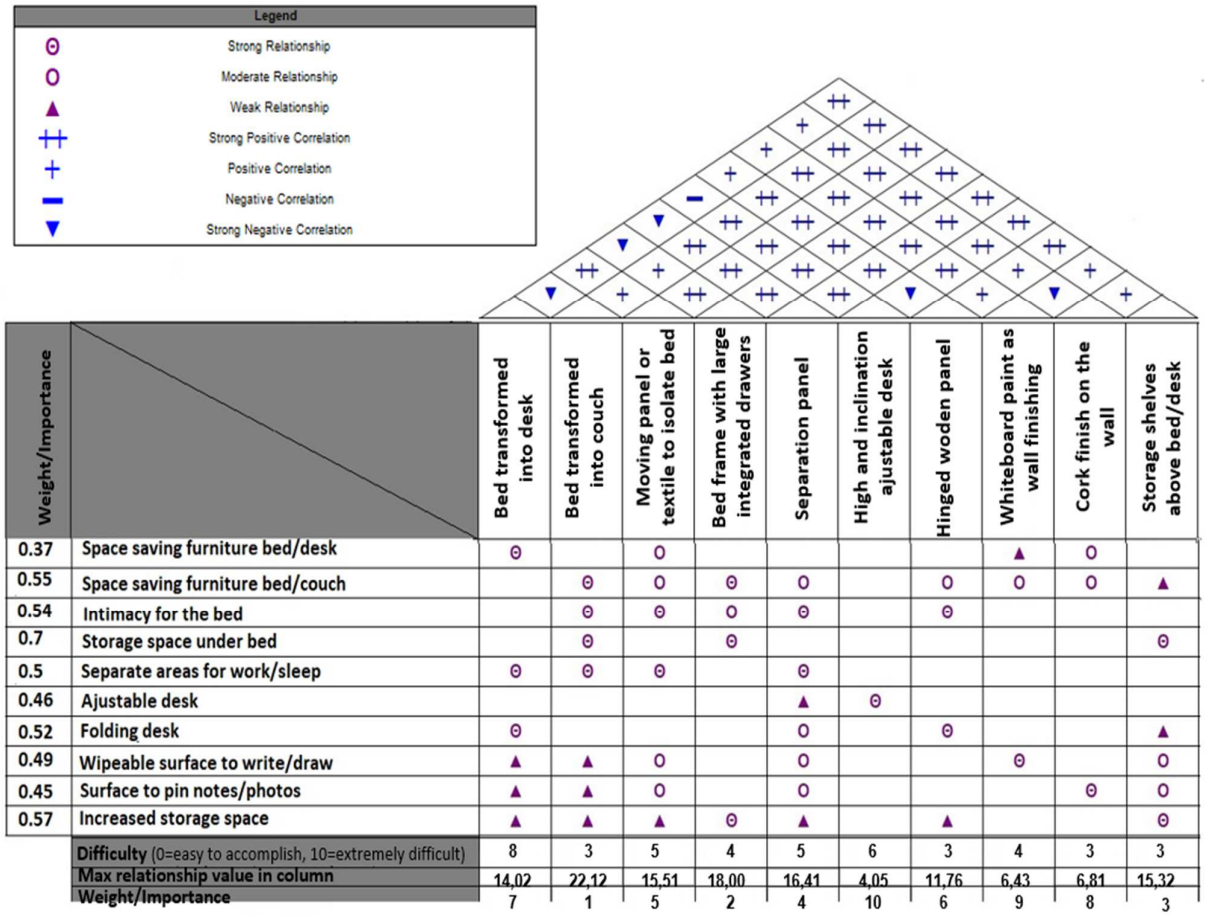

Fig. 4. The House of Quality for assessing relevant design requirements for the dorm room

The second and third most important design aspects are related to the storage needs and the fourth and fifth are concerning the intimacy and limitation of work and relax spaces.

For the desk, the folded option 7 is much more effective. But for the surface finish, the cork and the whiteboard finish have still similar values, a decision should be taken after a cost analysis.

The bed transformed into a desk option can be excluded due to multiple factors: the difficulty in implementation and the negative correlations with other DRs.

5 CONCLUSIONS

The voice of the student is an important factor in the ergonomic design of a dorm room. Based on his or her needs and perception of space, the

design can be adequately adapted to trigger satisfaction and even delight. Students feel engaged in the design, becoming a vital part of the process.

With the help of specialists 10 customer requirements have been proposed. After the present Kano analysis, we could understand the fact that students need and explicitly desire intimacy and storage in their rooms.

Requirements have been mainly categorized as attractive and one-dimensional. For a relevant decision making, the importance of the design requirements has been determined based on the relationship matrix between CRs and DRs in the first stage of the QFD method – the House of Quality. Thus, the way in which a quality characteristic will support and lead towards the satisfaction of a customer request has been assessed. It has proven difficult to separate work/study related requirements from the other functionalities of a dorm room as space constrictions require a multipurpose, mixed use of all areas and furnishings.

A need to separate work from living areas is required, yet further research is needed both at a room and building level. For the generalisation of the results, the 10 student requirements need to be analysed in different university contexts and with the help of additional quality engineering tools.

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Evaluarea atributelor de calitate relevante pentru proiectarea unei camere de cămin ergonomice în contextul românesc

Rezumat: Funcționalitatea unei camere de cămin și productivitatea activității studenților depinde de considerentele de amenajare a spațiului, cu toate acestea nevoile și dorințele utilizatorilor sunt rareori luate în considerare. Studenți cu sarcini și programe diferite, cerințe de spațiu și nevoi psihologice sunt cazați în încăperi standard. Lucrarea de față își propune să proiecteze cât mai eficient o cameră ergonomică pentru studenții români. În acest scop, metodologia Kano și instrumentul Quality Function Deployment (QFD) sunt utilizate pentru a discuta și a determina cele mai relevante atribute de calitate.

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