Kansei Engineering and Virtual Reality in Conceptual Design

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Abstract:

Originality/value – The paper describes a conceptual design process focused on client emotions that integrates the Kansei methodology with virtual reality systems.
Purpose – The virtual reality techniques, kinds of human-computer interfaces, and how the analyses in virtual reality environment can improve the conceptual design of products are described. The application of Kansei methodology and virtual reality techniques to the conceptual design of a multi-task equipment is also analysed.
Methodology/approach – The followed approach consisted in three main phases: the use of Kansei methodology to identify the users emotional needs; the building of digital models through 3D CAD software; the evaluation of some prototypes by some users in the Virtual Reality laboratory of the "Dipartimento di Meccanica" of Palermo, in order to choose the best concept.
Findings – Kansei Engineering integrated with virtual reality turns out to be the technique that better satisfies the requirements of a collaborative and emotional design; in particular it may be used during the iterative phases of design and verification process, as it would allow to test the usability of various solutions in a very powerful, fast and easy way.

Keywords: Kansei engineering, conceptual design, virtual concepts, virtual reality evaluation.
Paper type: Research paper

1. Introduction

The recent trends in the field of design show an inclination towards solutions that try to provoke certain feelings to people. All this leads to fix the attention on a human ability impossible to automate: the emotion. With the aim of explain the emotional process and to design products so that they can cause certain emotions in customers, a field of research called Emotional Design has been created. The emotional design studies the complex emotional relationships that connect objects to individuals; these feelings can be of unconscious kind, since we often have difficulties rationalizing our feelings. To understand the emotional design various methods were developed over the years; one of the latest is the so-called Kansei Engineering, which was developed in Japan starting from the seventies; it is able to translate customers' impressions and requests on existing products or concepts into practical solutions design, responding also to the latent needs of customers. In this paper Kansei methodology is applied to collect information on various aspects of a product, and in particular to a multi-task equipment for academic use eligible to receive and store tools needed in teaching such as an overhead projector, a laptop, a projector and any accessories such as loudspeakers, trasparencies, lecture notes. The Kansei methodology has been used to gather information on various aspects of the product and thus be able to design some concepts through solid modelling software, thanks to the data collected during the course "Fundamentals of product design". The nine concepts that have obtained the highest score were compared in a collaborative meeting in the virtual reality laboratory of the department, finally choosing the best model.

2. The Kansei Engineering and the conceptual design

2.1 User centred design and Kansei Engineering

Every industrial project is designed for humans; they interact with it through their physical-relational capacities, and the positive or negative outcome of the design process depends on the quality of this interaction. So it's necessary to implement an user centred project of the product. Consequently, it must take into account mainly the emotional needs of clients. In recent years areas of research, such as the Emotional Design, the Affective Design, Pleasure with products have been developed. These researches try to understand the users' personal impressions and make them describable, or at least measurable, to assess product solutions in accordance with emotional impact. The changing trends in users require new tools, integrating also emotional aspects in the development of the product. One of these tools is the Kansei Engineering; it is an engineering tool of great interest, since it is the only tool made specifically to quantify the emotional needs of users and to develop them into products. The term Kansei derives from two Japanese words, "Kan" and "Sei", which combined mean sensitivity or sensibility. According to the Japanese Society of Kansei Engineering, "Kansei is the integrated function of the mind and other functions that exist when receiving and sending signals. Filtering, acquiring information, estimating, recognizing, modelling, making relationship, producing, giving information, presenting, etc. are the contents of Kansei" (Schütte, 2005); then the Kansei is not only an internal process, but a process in constant contact with the outer world receiving information, processing it and reflecting it back to outer world.

2.2 Structure of Kansei Engineering

Although the procedure of Kansei Engineering seems to be heavily dependent from the context of individual research, there are many similarities in the procedures and instruments used for evaluation. Simon Schütte, of the Linköping University, has proposed a model of the structure of Kansei Engineering schematized in figure 1 (Schütte, 2005).

After choosing a domain, the idea behind a product can be described by:

- The semantic and
- The product properties

perspectives. Each of these descriptions explores a vector space; then these areas are analysed in relation to each others in the phase of synthesis. The data extracted during synthesis form input for the test of validity, which include various types of testing; through these results, the two vector spaces are updated and the stage of synthesis is carried out again. When the results of this iteration process are satisfactory, a model that describes how the semantic space and space of characteristics are associated can be defined.

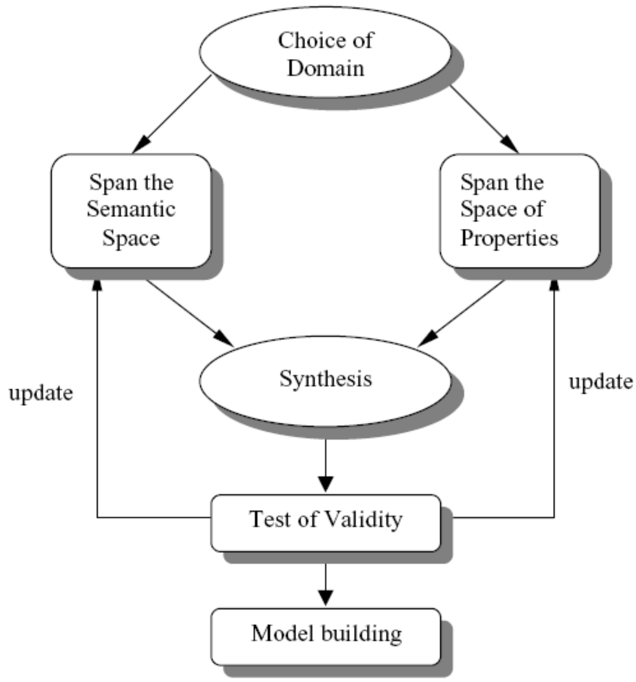

Fig. 1. Scheme of the Kansei procedure.

Choise of domain

The domain refers to the type of product under study (Nagamachi). The domain may refer to existing products, to concept product, and to design innovative solutions. The definition of the domain also includes activities such as the definition of the target group and market segment on which to focus the investigation. To this purpose data series are gathered through market research and interviews with experts.

Spanning the semantic space

Osgood (1957) introduced the Semantic Differential Scales method to quantify the significance to give some ideas or some words. It was based on a semantic scale through which it was possible to determine whether and to what content a verbal description is a symbol for a particular object. The spanning of semantic space is divided into three parts. First it has collection of words that describe the domain, then the selection of words that have a higher impact on the customer and finally the choice of Kansei words; if important Kansei words are not considered, the result can become useless, then it is better to select a higher than the necessary number of words to the necessary. In order to collect all possible words connected with the product, the following sources are used:

- Magazines;
- Pertinent literature;
- Manuals;
- Experts;
- Experienced users;
- Ideas, visions.

The Kansei is expressed either by words in most cases, or by other grammatical expressions; it is very important to translate into Kansei also innovative ideas and concepts. Only in this way Kansei Engineering can be used as a tool of creative product development, generating new and revolutionary solutions.

Depending on the considered domain, the Kansei words generally vary from 50 to 600 (Nagamachi, 1997) and it is generally considered advantageous to use the original number of words to avoid loss of information.

The process of selection of words with the highest impact on the client is the target of the second step, which uses different methods, depending on the existing context.

These methods can be divided into two main categories:

- Manual Expert Methods (eg. Affinity Diagram, choices of designers, technical interviews)
- Statistical Methods (eg. Factor Analysis)

The words catalogued in semantic scales can successively represent the semantic space accurately; the result of the third step is a list containing the ranking of the words selected.

Spanning the space of product properties

The exploration of the space of product properties provides for a range of activities similar to those of the semantic space. Again the product properties are collected by employing various resources such as technical manuals, interviews with experts, literature, competitive products benchmarking. Using just these sources, however, it is difficult to develop innovative products; then all the imaginable properties that can enter in the domain must be looked, even those not yet present on the market. To prevent the Kansei interview become too burdensome for the interviewer, properties that users consider most important are selected.

Tools capable of achieving the selection are:

- Pareto diagram (Ferrigno et al., 2006)
- Kano Method (Ferrigno et al., 2006)

After these methods are applied, selected properties are grouped into sets of product properties from which representative characteristics of each group are chosen, which will be used in the next step, the synthesis.

Synthesis

In this phase interactions between semantic space and space of the product properties are analysed. The attempt to establish these connections is the heart of the work of Nagamachi in the recent years on Kansei Engineering. The main technique to make this connection is the supply of a questionnaire to users, in order to assess their preferences regarding the concepts of product selected.

Test of validity

At this stage the data coming from the synthesis are analyzed and if necessary iterated. For example, relatively to the semantic space it can be run a factorial analysis of data acquired by synthesis and comparing them with results issued from spanning of the semantic space; comparing these two results words that have no effect on Kansei can be identified. Then data are sent again to the semantic space and if it's necessary only one iteration, these new words will use to build the model. Theoretically, this procedure might be applied to space characteristics, but it has not been tested yet.

Model building

When the test of validity give satisfactory results, the data acquired through the synthesis can be presented in a relational model. This phase is probably the most important of the methodology, because it does Kansei an instrument capable not only to connect the Kansei words with the product properties, but also to quantify by objective criteria these reports. The construction of the relational model is carried out by different linear or non-linear mathematical applications; the kind of model depends on the context, because emotions and feelings do not follow already encoded mathematical laws.

Constructing Kansei Engineering questionnaires

In general it is important to build a questionnaire in a way that is less disturbing for data quality and allows the respondent to fill in as much of his/her own opinion as possible. The structure of the questionnaire depends on various factors, such as purpose, respondent group, available resources, but also the researchers personal style.
The figure 2 shows two types of questionnaire.

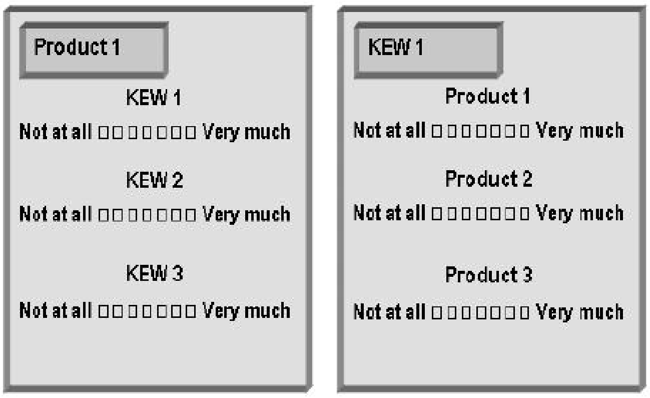

Fig. 2. Two types of questionnaires.

The type on the left shows a structure based on the Semantic scale, which is traditionally used in a Kansei survey; the concept of the product is indicated on top and evaluated according to different Kansei words. It allows rating the entities (products) separately according to the semantic dimensions spanned by the Kansei Engineering Words (KEW); the scale used for the assessment is 7 levels.
The example on the right is a modified version, which evaluates according to a Likert scale (Giordano, 2005); the Kansei word is on top and the products are rated below. This renders convenient to make a contemporary evaluation and a classification of products.
The questionnaire design can also greatly influence the response. For example rating the Kansei Engineering word "easy" before the word "precision" could result in a better rating for the second

word than as if it was given separately or in context with other words. So it needs to look for the right arrangement of words to submit to users, so that there isn't positive or negative influence in the response.

3. Conceptual design of a multi-task equipment for academic use

The Kansei methodology to identify emotional needs of users has been applied in the conceptual design of a multi-task equipment for academic use, suitable to receive and safely store (against theft) a projector, an overhead projector, a notebook, loudspeakers, books, transparencies and whatever is necessary for teaching.
The approach also includes: the construction of models in CAD environment by Solid Edge software; the rating of some models in the virtual reality laboratory of the "Dipartimento di Meccanica" of Palermo to select the best concept. To the project realization 12 students in specialist degree of Mechanical Engineering of the course "Fundamentals of product design" have attended, which have been asked to express their opinion on the project through interviews and questionnaires.
The phases of design are schematized in figure 3:

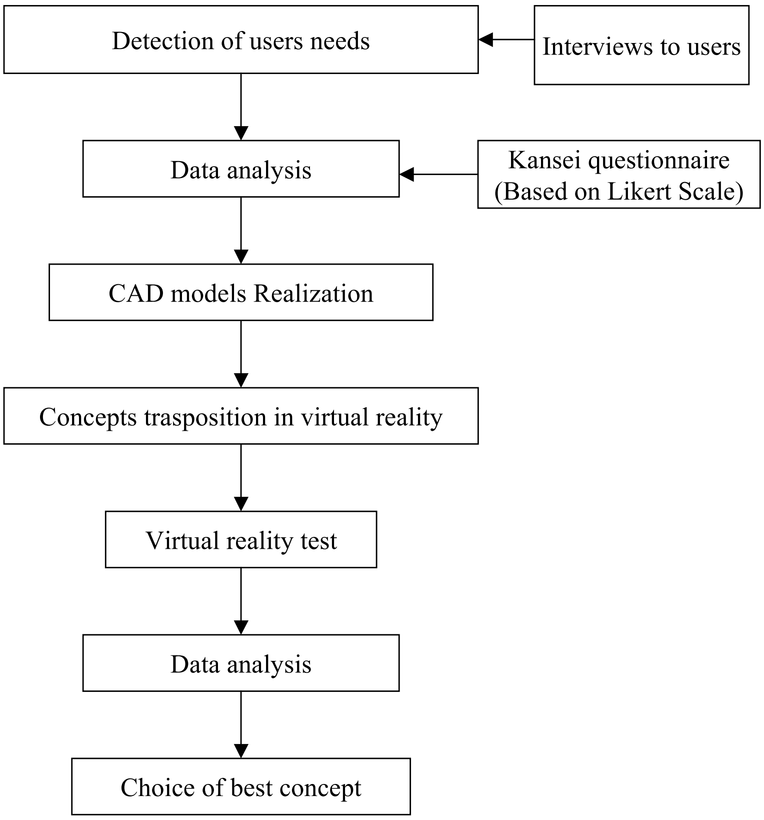

Fig. 3. Scheme of project methodological phases.

3.1 Users needs detection

The first phase consisted in a search for the Kansei words; to do that it was primarily chosen the domain within which to do the analysis. As interlocutors were chosen students of the course "Fundamentals of product design".
The next phase provides for the exploration of semantic space and exploration of the space of the product properties, by which one arrives at the synthesis stage. From an initial analysis some selection criteria, shown in fig. 4, were chosen:

- Portability;
- Handling;
- Economy;
- Solidity;
- Aesthetics;
- Configuration variability;
- Easy connection to the network.

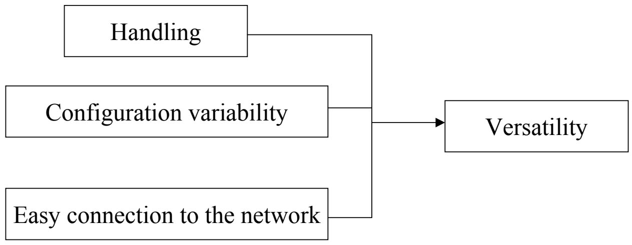

Fig. 4. Versatility scheme.

In a second step handling, configuration variability, easy connection to the network were grouped in the word versatility (see fig. 4).

Selection criteria	Total weights
Portability	15
Versatility	10
Economy	9
Small dimensions	10
Duration	10
Solidity	10
Constructive simplicity	8
Aesthetics	8
Use of recycled materials	10
Effective anti-theft system	10

Table I. Selection criteria weights.

The following needs regarding the space of product properties have emerged:
- Small dimensions;
- Duration;
- Constructive simplicity;
- Use of recycled materials;
- Effective anti-theft system.

The selection criteria were evaluated interviewing interlocutors, divided into groups, assigning weights to each word, by ensuring that the sum of the weights were 100. Weights equal to 15, 10, 8, 4 were chosen.
The table I shows the weights assigned to different selection criteria.

3.2 Kansei questionnaire

At a later stage has been constructed a Kansei questionnaire taking into consideration the words *portability* and *versatility* that better connect to product usability, incorporating the handling, the configuration variability, easy connection to the network and the ability to move the mobile more easily. The word versatility was combined with *aesthetics*.
Therefore it was decided to investigate:
- for versatility and aesthetics,

  opening systems choosing between two different opening systems for the upper and lower part of equipment and between types of external shelves;
- for portability,

  choosing between three types of wheels and three types of handles.

For versatility and aesthetics were chosen as factors: the shape, the material and the colour, each considered on three levels, so as to have 27 possible combinations, which correspond to an equal number of concepts.
For portability was considered only the combination of the three types of wheels (fixed, pivoting, spherical) with three types of handles (two simple handles, bar, two ergonomic handles), for a total of 9 combinations. The alternatives were considered on the basis of solutions already on the market and new solutions to try to innovate the product.
The table II shows the constructive solutions related to the versatility and aesthetics, based on type of structure, material and colour:

Factors	Levels	Upper opening system	Lower opening system	External shelves
Type (A)	0	Folding panels	Drawer(s)	Sliding
	1	Shutter	Door	Sliding
	2	Door	Door	Folding
Material (B)	0	Plexiglas	Plexiglas	Aluminium
	1	Aluminium	Aluminium	Plexiglas
	2	Recycled plastic	Recycled plastic	Aluminium
Colour (C)	0	Dark grey	Dark grey	Dark grey
	1	Pale grey	Pale grey	Pale grey
	2	White	White	White

Table II. Constructive solutions.

The evaluation of the concepts was carried out using a Likert scale, with the possibility of giving a vote from 1 to 10 to constructive solutions, according to the Kansei word used.
For portability the best combination of the types of wheels and the types of handles was *ergonomic handles + spherical wheels* with a score of 8,75. From data analysis were selected for the versatility and aesthetics the nine constructive solutions with the highest scores (see table III):

Concepts	A	B	C	Mean-scores
16	1	2	0	8
26	2	2	1	7,5
7	0	2	0	7,42
13	1	1	0	7,33
14	1	1	1	7,25
5	0	1	1	7,25
25	2	2	0	7,25
8	0	2	1	7,17
18	1	2	2	7

Table III. Mean-scores of concepts.

These nine concepts are based on three basic constructive solutions, which are extended by changing the materials and colour. Figures 5, 6 and 7 show the closed configuration of the three basic constructive solutions. The names were chosen by users groups.

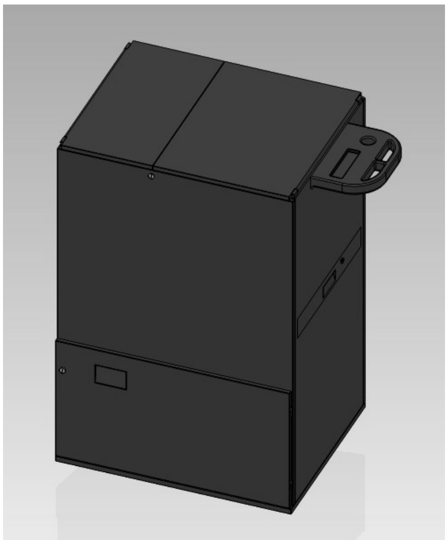

Fig. 5. Spider.

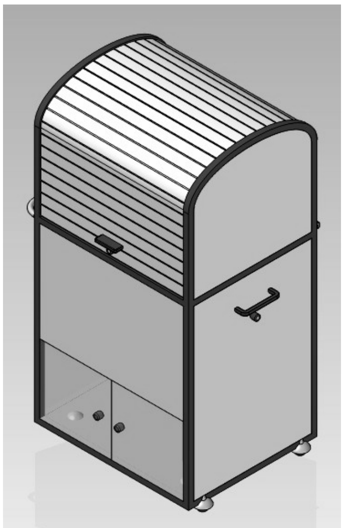

Fig. 6. Multitask-compact.

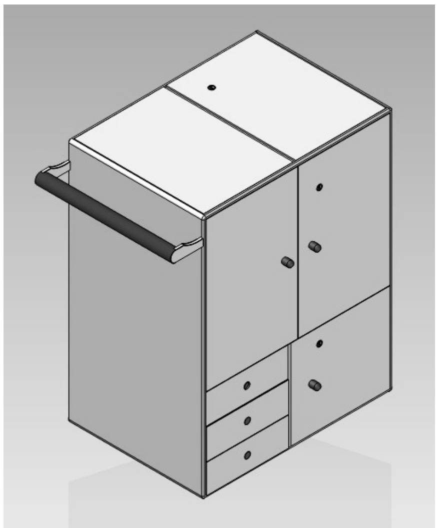

Fig. 7. Darma.

4. Implementation of Virtual Reality in the conceptual design

The use of conventional CAD systems has been effective and profitable in the design process of new products; however it is largely confined in the last stages of planning. The traditional CAD systems are not capable of supporting the activities of the conceptual design, because we need for a more intuitive and natural way to consider the human-computer interaction.
A system of inputs for modern computers should be able to process 2D and 3D input signals; moreover the usage of CAD in the conceptual design should allow designers to concentrate more on the creative aspects of design, as well as on problems of interaction. The technology of virtual reality has emerged as an extension of 3D graphics performed by the last generation user-computer interfaces, which replicate a realistic functional environment through multiple sensory channels (vision, hearing, touch…). Virtual reality is seen as a very powerful tool in developing and implementing more natural and intuitive interfaces; it is generally recognised the need to integrate the technologies of virtual reality in the process of product development, especially in the conceptual stage, giving new contributions to the field of CAD. Technologies such as haptic interaction and stereoscopic display can help in the process of product design already in the early stages of design, combining with the assisted software design.

4.1 Concepts evaluation in virtual reality session

An evaluation of concepts by virtual reality was performed. In order to evaluate the 9 constructive solutions a questionnaire based on the Likert scale has been formulated, with a possible judgement from 1 to 10. The concepts were presented randomly. Table IV shows the concepts classified on the basis of final score:

Order based on scores	Concepts	A	B	C	Mean-scores
1	5	0	1	1	7,75
2	26	2	2	1	7,75
3	14	1	1	1	7,67
4	13	1	1	0	7,58
5	18	1	2	2	7
6	16	1	2	0	6,92
7	8	0	2	1	6,58
8	25	2	2	0	6,58
9	7	0	2	0	6,5

Table IV. Concepts order based on scores.

On the basis of the results it has seen that two solutions have the same score of 7,75: the concept 5 and the concept 26. By majority vote the concept 26 was chosen. The solution doesn't coincide with that of the Kansei questionnaire (concept 16). To some extent, this highlights the important role that evaluation in a VR environment can play. However, the concept 16 and 26 were further compared. By majority vote has been chosen the concept 16 as the best.
This solution provides a multi-task compact type, with as upper opening system a shutter and doors as lower opening system; recycled plastic was chosen as material for opening systems, while aluminium for shelves; colour dark grey was chosen. To the concept were also added features relating to the portability that have been chosen by users in the Kansei questionnaire, that is ergonomic handles and spherical wheels.

The figure 10 and 11 show the final chosen concept from two different points of view:

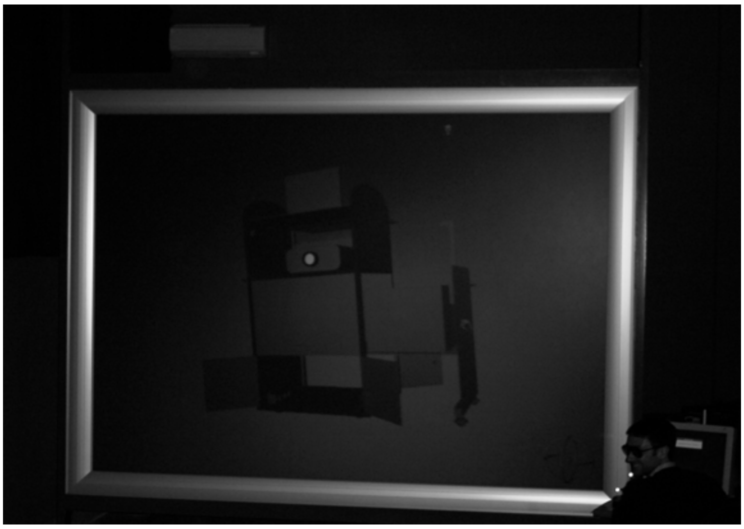

Fig. 9. Virtual Reality evaluating session.

Fig. 8. Virtual Reality evaluating session.

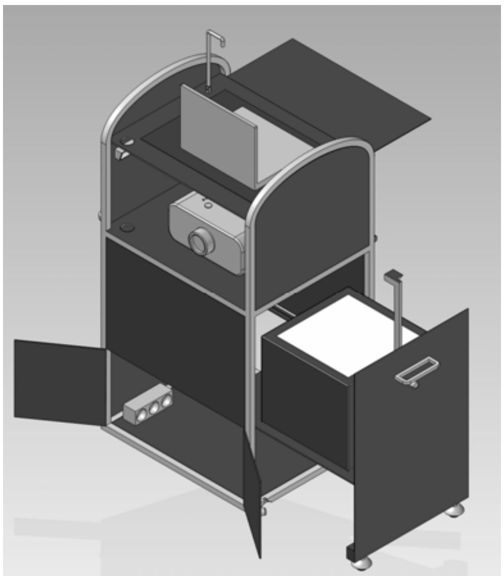

Fig. 10. Chosen concept (A1-B2-C0).

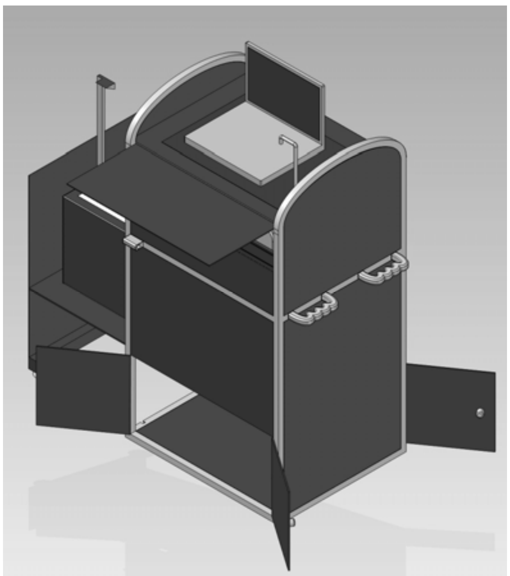

Fig. 11. Chosen concept (A1-B2-C0).

5. Conclusions

In this paper, in the light of recent developments in the field of design and considering the more and more larger diffusion of emotional design, it was performed a conceptual design process focused on client emotions. The procedure is characterized by the use of Kansei Engineering combined with virtual reality techniques to enable a quality improvement already in the stage of conceptual design of the product.

It was carried out the design of a multi-task equipment for academic use; it was decided to simplify the Kansei procedure so that users could answer in the best way the questions, without get bored, giving in this way the most reliable results. The concept based on the characteristics that had the highest score in the Kansei questionnaire was chosen. However a confirmation test was required, probably for the information lost due to the simplification of the procedure.

Certainly the virtual reality has helped the design; through VR users have been able to verify directly the solutions chosen by the questionnaire and then better to assess the best constructive solution. Kansei Engineering integrated with virtual reality is certainly the technique that better satisfies the requirements for an approach to participatory design; in particular it may be used during the iterative phases of design and verification process, as it would allow to test the usability of various solutions of the project improvement.

References

[1] Bruno, F., Mattanò, R.M., Muzzupappa, M., Pina, M., 2005, *Partecipatory Design in Virtual Environment*, Proc. of XVII Ingegraf – XV ADM, Sevilla, June.

[2] Di Gironimo, G., Lanzotti, A., Matrone, G., Papa, S., Tarantino, P., 2007, *Concept Design of a Railway Coach: Quality Elements Identification through a Kansei-VR Approach*, Conference Publication, Proceedings of IPMM Conference, Salerno (Italy).

[3] Ferrigno, S., Lo monaco, V., 2006, *Strumenti e metodologie orientate al cliente, un caso studio su un prodotto sanitario: Progettazione emozionale di una carrozzina per la deambulazione dei pazienti affetti da ritardo mentale*, Thesis, supervisors prof. Lombardo A., Ing. Barone S., Department of Management Engineering, University of Palermo (Italy).

[4] Grimsæth, K., 2005, *Kansei Engineering – Linking emotions and product features*, Undergraduate Thesis, Norwegian University of Science and Technology (NTNU) [Online]. Available:
http://www.ivt.ntnu.no/ipd/fag/PD9/2005/artikler/PD9%20Kansei%20Engineering%20K_Grimsath.pdf

[5] Lee, S.H., Harada, A., Stappers, P.J., 2002, *Pleasure with Products: Design based on Kansei*, published in Green, W. and Jordan, P., “Pleasure with Products: Beyond usability” ed. Taylor & Francis, London, p. 219-229.

[6] Schütte, S., 2005, *Engineering Emotional Values in Product Design – Kansei Engineering in Development*, Doctoral Thesis, Institute of Technology, Linköping Universitet, Sweden. ISBN: 91-85299-46-4.

[7] Schütte, S., Eklund, J., Axelsson, J. R. C., Nagamachi, M., 2004, *Concept, Methods and Tools in Kansei Engineering*, published in “Theoretical Issues in Ergonomics Science”, Vol.5 (3), p. 214-232.

[8] Ye, J., Campbell, R.I., Page, T., Badni, K.S., 2006, *An investigation into the implementation of virtual reality technologies in support of conceptual design*, “Design Studies vol.27, p. 77-97.

Web sites:

[9] http://www.aero.polimi.it/~bianchim/bacheca/analisi_di_pareto.pdf
[10] http://www.valutazioneitaliana.it/riv/num7/giordano.pdf