An analysis of the benefits of ethnography design methods for product modelling

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Abstract. The essence of modelling is to reflect the studied piece of reality in such a way that best describes the selected elements of the designed system. A model is used in design to optimize the structure and parameters of the constructed object and is a tool for assessing the quality of construction, eliminating weak links and ensuring adequate safety components. In view of the aim of modelling, it can be divided into functional modelling, showing the complexity of the object, and reliability modelling, specifying its states at variable threshold values. In design, modelling allows for significant savings in resources that would otherwise be spent because of problems appearing at the prototype stage, but also during production or in the course of using the product. In the practice of ergonomic design many problems could be avoided if early enough in the design process the values of parameters and their relations would be taken into account through modelling. On the other hand, the modelling process can be costly and time-consuming to carry out, and against the currently pervasive lean production it is a highly undesirable factor. Therefore, the modelling process should be supported with the use of appropriate cognitive techniques namely ethnography design, which would determine inadequacies of existing models as well as indicate the equivalent conditions for modelling. The justification of the use of this technique results both from the possibility of providing additional information, as well as the opportunity to “test” the phenomena affecting the design process. Ergonomic modelling tests developed solutions towards their adaptation to users’ anthropometric, biomechanical and psychomotor characteristics, as well as behaviour patterns. However, knowledge of the latter and achieving a sufficient ergonomic and functional quality of proposed solutions often requires the use of the ethnography design approach. The aim of this article is to test the practical application of ethnography design methodology in product design and to analyse the benefits of its use. The analysis is based on effects of its application with the support of product design from various industries, along with a discussion of the method’s limitations. Among benefits of ethnography design, the greatest proved to be providing knowledge of nonspecific user behaviour previously unknown to designers, which when rendered by models allowed to develop innovative solutions.

1. Introduction
In the broad sense the essence of modelling is to reflect the studied piece of reality in such a way that best describes the selected elements of the designed system. A description of the elements gives knowledge about how they operate in different variable conditions and the ability to test the values
they adopt. It is not different in the case of ergonomic modelling for the design of products, which are to respond to the needs of specific groups of users. A model is used in design to optimize the structure and parameters of the constructed object and is a tool for assessing the quality of construction, eliminating weak links and ensuring adequate safety components [1]. In view of the aim of modelling, it can be divided into functional modelling, showing the complexity of the object, and reliability modelling, specifying its states at variable threshold values [2]. Often there are performed for achieving specified feature of the system [3]. Depending on the way of reproducing reality, models may be mental and material, which due to the possibility of testing in similar material conditions have a greater cognitive value. In design, modelling allows for significant savings in resources that would otherwise be spent because of problems appearing at the prototype stage, but also during production or in the course of using the product. Models also have an invaluable cognitive nature, because they allow for testing of a particular scale and complexity of a specified slice of reality. However, in order for them to be used, it is necessary to know the relationships and parameters that are necessary for a possible complete description of the assumed fragment of reality.

In the practice of ergonomic design many problems could be avoided if early enough in the design process the values of parameters and their relations would be taken into account through modelling. On the other hand, the modelling process can be costly and time-consuming to carry out, and against the currently pervasive lean production it is a highly undesirable factor. Therefore, the modelling process should be supported with the use of appropriate cognitive techniques namely ethnography design, which would determine inadequacies of existing models as well as indicate the equivalent conditions for modelling. The justification of the use of this technique results both from the possibility of providing additional information [4], as well as the opportunity to “test” the phenomena affecting the design process.

2. Need for supporting product design through modelling

Modelling is a means to achieve a greater quality of the designed solutions, and this commitment is a fundamental duty of every designer [5], which is consistent with the trend of corporate social responsibility [6]. It is worth noting that a product, being any artificial object constituting the result of processes and used to address the specific needs and expectations of the user, may have a modular structure, of which the “real” part can be only a fragment of the whole. Besides the physical structure, the product will have a functional structure, which in most of today's products will manifest as its mechatronic property. This implies the need for modelling on several planes, reflecting the states of all elementary members. An additional difficulty in this regard is the need to reflect nonlinear relations, which are characteristic in work systems [7]. Product modelling is a necessary function of the design process due to its ability to provide [8]:

- possibility of carrying out analyses of individual elements joined to make a whole, taking into account the conditions of individual parameters, e.g. stress analyses or value chain analyses within the manufacturing process, modelling allows for the inclusion of elements of the whole in a structured mathematical model – quantity models - Computer Aided Engineering – applied by for example, Abaqus/Explicit,
- prototyping capabilities, which may rely on kinematic functionality, ergonomic verification, analyses of the possibility of assembling individual components, or the dynamics of elements and units – which involves a qualitative analysis of the proposed solutions - quality models, which can occur at different levels of generality.

More detailed modelling processes can be targeted to achieve a particular specific result, for example: clarify and simplify the interaction between elements, confirm the fulfilment of certain restrictions on the process, verify the accuracy of the new element of the system before its implementation. Due to the formalization of processes in statistical analysis and reliability modelling, even those of a nonlinear nature, in the following sections mainly qualitative models will be analyzed.

Of particular interest in the field of product modelling is attaining functional quality [7], which is generated during the confrontation of expectations of the user with the quality provided by the product
and the product’s impact on the user through its ergonomic action, which is the sum of many interconnected components [10]. This type of modelling is particularly applicable in the case of products which have been altered in their essence from previous versions (lack of abilities to verify the evolution), or the use of solutions on a new audience.

3. Essence of ethnography approach in design

The ethnographic approach is a method which helps to understand the actions of people in order to better adapt newly designed products, services and processes [11]. At the same time, ethnography can be used to examine the effects of implemented changes in the products, services or processes [12]. Ethnography design is primarily ergonomic because it solves the issue of designers having knowledge of the principles of constructing products but lacking insight into the actions and operation of people [13]. Meanwhile, the implemented products change the behaviour of humans on which they have an impact. Ethnography design allows to control the ergonomic quality of products through an in-depth study of the functionality and user interaction with the product [14]. Between the fields of design and ethnography, there exist also many ways to integrate knowledge and experience, e.g. through joint training of specialists in both fields, exchange of knowledge and experience in the design process, mutual participation of designers in the observations. Also, actions in the field of ethnography design are focused on the appropriate methods of interaction, which will not be suggestive to users and will allow to obtain information [15]. The main principles for conducting research using ethnography are based on four assumptions organizing and distinguishing ethnography from other methods [13]:

1. natural environment – ethnography is based on carrying out research in the field, among the target audience; it should be understood that there is a commitment in ethnography to investigate the activities of people in their everyday living and working conditions;
2. holistic approach – stems from the belief that learning about real problems in the so-called “present state” and understanding the rules of conduct and choices of people can be possible only through the observation of reality in the whole context of work and life of humans;
3. descriptive approach – during ethnographic observations, the researcher takes notes or records videos to later be able to analyze the observed events and findings that are relevant to the research. It is important that during the observation one retains a “non-critical” attitude;
4. “from the point of view” approach – involves an attempt to empathize with the observed person or technical object or phenomenon and to attempt to understand how a given person perceives their space and task; this approach has a great advantage over survey methods, because, as opposed to the survey, it is not based on pre-established findings.

The first two of these characteristics may seem contradictory to the idea of modelling, because it implies in the majority of cases a departure from the natural environment as well as it is not always possible to carry out a holistic analysis of a system. This results in the need to use modelling based closely on the natural design environment and a comprehensive coverage of the tested phenomena.

Found in literature are the following ways ethnography could be involved in technology design [16]:

- identifying “sensitizing” concepts,
- developing specific design concepts,
- driving innovative technological research.

Another role which can be played by ethnography is evaluating design [17], where the use of ethnography is conducted as a common sense check up on the design. Another important function of ethnography in design can be context awareness [18]. This feature is particularly important in cases where the designer receives guidelines regarding design, not knowing its environment, which will be important to carry out specific functions in reality.

In ethnographic practice observations are a valuable source of data also because users are unable or unwilling to articulate their specific needs or concerns. It commonly happens that people deliberately mislead, are confused, are afraid to say what they really think, e.g. for fear of losing their jobs, they have no knowledge on the topic and thus are not able to speak, they have problems with making contact, or want to be liked and distort their real thoughts, often unconsciously. This is the main
motivation for the application of observation and the result is that ethnography design can be applied in the design of products for the elderly [19].

4. Application of ethnography design in product modelling

The assessment of the degree of representation of reality by the created model in the process of product design is in fact an assessment of the prescribed quality of specific patterns of action of a specific group of users to the functional diagram - Figure 1.

![Figure 1. Quality of product modelling based on ethnography design](image)

A typical application of ethnography design in the design process is shown in Figure 2. Ethnography design has its uses in the development of user requirements during the initial stages of the design process, which are processed into a list of requirements, which in turn is analyzed through the use of simulations.

![Figure 2. Typical ethnography design application](image)

In the majority of cases, the use of such a solution has practical considerations. Very often a needs analysis is accompanied by an observation of the existing conditions (ethnographic approach), and from here any identified needs of users are derived. However, this leads to a lack of opportunities to test the proposed solutions, and the simulation applies only to those aspects which are considered important to the designer. By way of simulation, models that allow to examine reality tend to be developed, but not tested is their quality in terms of reflecting reality beyond the selected aspects - which forms the main assumption of classical modelling.
Figure 3 shows a slightly different structure, which forms an extension of simulation conditions by the addition of elements of testing the real application of proposed solutions by the target users. On the basis of these activities, new variables or design parameters can be determined and a multi-criterial representation in terms of individual elements can be evaluated. This approach requires contact of designers with the tested group of users that could be subjected to a simulated observation while using a part of the solution. Such an approach is possible with the use of modern production techniques (e.g. 3D printers). There is also the possibility of creating equivalent structures, which in certain limited areas will simulate an ethnographic verification of solutions, but will not allow for the disclosure of unknown applications. Such a structure equivalent to the real, can be a mechanical or logical system similar in operation to the real – the shaking of hands when placing a key in the lock can be replaced by a mechanical oscillator which will verify inertness during the use of a lock by a person with reduced manual dexterity. However, only ethnography design may lead to the discovery of specific ways of actions of users related to such a dysfunction, such as the need to limit the turning force of the key, which may not be detected due to it being covered by the first need of the user. In the case of applying ergonomic modelling in unclear conditions, the quality of representation could be reliably assessed, e.g. in modelling the adaptation of an anthropometric human and other objects and the ability to exert forces excluding unspecified functional overlaps of dynamic anthropometry. In turn, modelling in a more theoretical-cognitive sense will be possible with the use of ethnographic approach only at the level of identification during model creation, and its verification will not be possible, as is the case with modelling error [20]. An interesting modification of the ethnographic approach is the use of technical means such as video-recorders that can recognize certain states in the real system [21] and transfer them to the theoretical model. A more complex aspect is to assess the quality of the transfer of reality during modelling of heuristic and thought processes, in this area one can rely on artificial neural networks [22], however, the quality of representation with the use of ethnographic approach may rely only on principles similar to the “black box,” as an assessment of the degree of conformity between input and output parameters for both systems.

5. Need for ethnography design in product modelling
Ethnography design has significant advantages in the modelling process, however there are contraindications to its use due to it increasing the time intensiveness of the design procedure and the possible obstruction to proceedings. The identified needs for ethnography design are presented in terms of the various stages of the design process – Table 1.
Table 1. Modelling abilities based on ethnography design

| Design stage [23] [25] | Application of ethnography design | Modelling abilities based on ethnography design (examples) |
|------------------------|-----------------------------------|----------------------------------------------------------|
| study of problem situation | very large | ability to transfer analysed situation to different environments and verification of relations with changed input parameters |
| determination of needs | very large | simultaneous observation and construction of a model of needs and a verification of its applicability |
| determination of major need | large | analysis of the variability of needs depending on the group of users, extended observation of different groups of stakeholders |
| study of ability to achieve main function | large | search for existing solutions along with their environment serving to achieve the main function |
| design assumptions | limited | fragmented supplementation of construction knowledge with information related the impact of the environment – immediate surroundings of the project |
| presentation of solution concept | limited | verification of converge of proposed solutions in a previously developed model of needs |
| preparation of initial designs and their verification | very large | possibility of transferring the testing process to the realm of selected groups of users with specific needs (elderly and disabled) |
| variant selection and preparation of detailed technical design | negligible | does not apply at this stage of the design |
| prototyping | very large | possibility of partial representation of reality and concurrent testing – transferring solutions which are harder to test in reality to the virtual space simultaneously inputting real data – e.g. human method of operating a vehicle |
| product manufacture | limited | modelling at this stage is limited to minor revisions resulting from the manufacturing process – installation or application, and in view of the available technical facilities – design for manufacturability |
As indicated in Table 1, the most relevant application of the ethnographic approach in design is in the early stages of design, while establishing the criteria and usage needs. In subsequent phases, when it comes to limiting the number of concepts, overlooking crucial and hidden needs of users may result in that the project does not achieve the right level of functional and ergonomic quality. It should therefore be noted that the use of the ethnographic approach in ergonomic design beyond the obvious initial identification phases occurs in the case of:

- complex solutions, with an unspecified level of quality,
- solutions for a broad group of diverse users, with different cultural norms and procedures,
- designer’s lack of knowledge concerning the environment of the proposed solutions or the existence of significant levels of uncertainty in his understanding,
- information regarding undetermined problems in the application of the proposed solution by a specific group of users.

The applicability of the ethnographic approach is also dependent on the available resources of time and money, however in most cases the effect obtained with its help will exceed the incurred costs.

6. Practical application and benefit analysis of the ethnography design approach

The vast majority of researchers examining the ethnographic approach in design focuses on the characteristics of the method, its uses in teaching [26], describing examples of applications [27] and not considering simultaneously the practical applications as well as the scale of the achieved results. This is justified due to the complexity of comparative studies that would allow to reliably evaluate the effectiveness of two design approaches differing only in the application of ethnography design elements, however, this does not convince a wide group of designers to apply the approach.

The effectiveness of this approach can therefore be measured only on the basis of an absolute evaluation accumulating probably many other factors. Virtual reality is an area of particular applicability of the ethnographic approach, though this concerns not so much the group of designed products, but tools supporting design [28]. Often the ethnographic approach is indicated as particularly adept at discovering new products [29] or especially for data acquisition during the design process, which the designer does not have [30]. A significant problem in this regard is the belief of designers that they do not have enough information to design a solution. The ethnographic approach is also indicated as one of the key elements of the success of the Xerox company due to the creation of a research team - Xerox PARC [31] which was responsible, among other things, for the development of an interface scheme based on a significantly highlighted quick copy button, adapted later by all manufacturers of copying machines. This and many other design solutions based on the principles of ethnography design indicate the approach’s potential, but in many cases it is not possible to distinguish the effect of the applied changes because of the uniqueness of design processes and the variety of the means used to achieve a product with a high functional quality.

7. Conclusions

The typical application of the ethnography design approach in the design process has transferred from the initial stages to the next, allowing for the testing of solutions on a smaller sample of users prior to releasing the finished solution to the market. Such concurrent modelling of the analyzed reality on further, and at the same time sufficiently early, stages of design can allow for the ability to choose better decisional variants, which could have been eliminated due to the lack of knowledge of all the testing environment’s parameters. Ethnography design is also associated with ethical issues and is in line with the idea of participatory design. It should be noted, however, that it must be complementary with respect to the standard stages of design, and the selection of the research sample must allow for achieving results that do not disturb the various partial objectives. Selection of appropriate target groups is crucial, because there is a great danger to adapt non-standardized properties, which are rare in a group of users and that can exclude others – the so-called design antinomies. For this reason, taking on the ethnographic approach can also be difficult, however, the possibility to supplement the shortcomings of standard modelling is worth the risk.
A salient issue for future studies is to demonstrate the effectiveness of design enriched with the ethnographic approach, which is particularly important because of the time and cost effectiveness of modern design, which seeks, using approaches such as concurrent design, to maximally condense the design process. The problem in this regard may be the necessity to use qualitative changes in the assessment of design procedures, which is always less attractive than quantitative changes (e.g., in shortening the design process). Perhaps the solution to this problem is to widen the universal approach with the ethnographic paradigm, which for declarative statements about the need for participatory approaches would allow to develop methodologies ensuring this participation.

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