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INNOVATION FOCUSED TECHNIQUES OF IDEA GENERATION IN THE DEVELOPMENT OF CHILDREN'S TOYS

Balázs VIDOVICS
University of West Hungary, Faculty of Wood Sciences,
Institute of Product Design and Manufacturing

Abstract:

It is widely accepted that in innovative (original) design the early phases of the design process are the most critical. During the years in the practice of a children’s toy design course in the Industrial Design Engineering Program at Budapest University of Technology and Economics, it has been observed that, in accordance with the literature, students have the most serious challenges in the development steps which require the typical creative abilities, which can also be found in the literature as essential designers’ skills. Accordingly, clarifying and defining the problem in the specification phase, avoiding the fixation of the archetypes and trivial solutions, and generating a large number of ideas in the conceptual phase are found to be critical to be supported. Results of methodology research and development for the above mentioned aims are presented in the paper.

Keywords:

conceptual design, innovative design, idea generation, solution space, I-SWOT

1 INTRODUCTION

Children’s toy design course is a mandatory in Industrial Design Engineering BSc Program being one of the ‘Integrated Product Development” courses, and dates back for more than fifteen years. The design task described in the initial project assignment is always the same, i.e. to design an innovative skill-developing toy for kindergarten aged children. The semester project should be carried out partly in individual and teamwork. The design process follows the German classic school [1]. There has been several design methods and tools introduced to the course throughout the years, still students struggle with typical challenges of the designer.

Design process models describe the design process, mainly from the information content and information flow point of view. It utilizes the approach that the input information is processed by the designer they contribute, and eventually the information is objectified. The so called integrated development models prefer the information-based approach, it integrates the stakeholders, their roles, points of view, also the processes, and i.e. the evaluation and selection steps are aimed to be kept within the quality limits required by the stakeholders. The information based approach has a major finding; the design process evolves from a status of lack of information (design problem) towards a complete state of knowledge (product). This can be considered as a learning process, which approach has significance in consideration of gaining process knowledge. The descriptive design process models are suitable to define the processes considering the inputs and outputs, so the designer knows exactly from which input information they need to get to what state. At the same time the referred models do not give exact design method or tool for the designer how they should proceed from one step to the other in the design process.

The classification of design types from Ullman [2] is worth to be studied from the aspect of how well the design tasks could be supported or even be algorithmized, and how much is the role of the designer, as well. Taking into consideration that all the design steps of the whole design process can be classed in the typology, it has to be studied, in which design phase the certain tasks of a type occur and what is the weight they are represented. Considering the novelty content the classification of Olson et al. [3] is used. The meaning of innovation hereinafter will be defined as novel to the market, novel to the designer. This is basically the new product development (NPD), Olson applies a marketing approach. In this latter case the specification and conceptual phases have significant importance, since the designer has the highest freedom and chance to incorporate innovative content to the product (see also “the design paradox” in [2]).

From the other way around, the specification and concept generation phases have the highest importance in the new to the market type of design problems. This also implies that the marketing approach has to be stressed. Within those phases it is really important to provide the designers with prescriptive models, specific methodology and tools [4]. The quality control and project management aspects of a design process carried out in an organization could only be realized in a systematic designer activity [5]. Product design in Industrial Design Engineering at BME is regarded as a systematic and structured activity, purposeful and goal-oriented. Due to its complexity, designing requires a structured and systematic approach as well as moments of creativity.

2 RESEARCH

2.1 Overview of methodology framework

The prescriptions referring to the conceptual phase in the classic school did not reflect the integrated approach, so from the technical application point of view the following remarks can be made. Primarily it provides support for problems of technical character or for machine design exactly. It is an advantage that the creation and assessment phases are distinguished, but for the creation phases only recommends creative group techniques as intuitive methods, which are mainly Brainstorming-type procedures. Also in the way of thinking of the classic school the need for generating numerous, competing alternatives appears, but e.g. Pahl and Beitz do not consider this as a key issue. A further disadvantage is that the methods are not innovation oriented, the designer’s activities, in with the inventive thinking and the creation of innovative products are not supported to the desired extent [6].

According to the literature and the praxis we tend to overrate the significance of team work. Of course collaboration in multidisciplinary teams is an important component of the designer’s competence profile. Engineering, business, design, social sciences should be combined as they are combined in our real life experience [7]. From the viewpoint of innovative NPD other aspects should be studied. Throughout the analyses of the literature on the descriptive models and the processes of original (creative) problem solving, also by the observations made in the framework of our research we also ended up with the findings of von Stamm [8]: “As opposed to commonly held opinion, creativity, the act of coming up with an idea, is an inherently individual act – it is the development of an idea and the implementation where the team is needed.”

Without studying the relationship between the design science and psychology, we argue that the description of the process of phases of specification and conceptualization in design science is matching well with the description of individual creative problem solving process. This might be behind the fact that in Delft the same descriptive model is once being called the Delft Product Development Process, the other time Delft Process of Creative Thinking [9]. The mentioned parallelisms could also be found in the design science literature, furthermore certain methods (e.g. Creative Problem Solving, CPS), as a transition from descriptive to prescriptive models [10]. In the design methodology research of ours we assume that discovering the characteristics and supporting the process of individual problem solving the phases of specification and concept generation become richer and innovative in consideration of the results.

To describe the characteristics of the individual creativity and problem solving process several psychology schools were born, which sometimes represented significant differences in their points of views. On the basis of the colorful picture one thing can be stated for sure; the science of creativity is trans-, multi-, or interdisciplinary [10]. In our case the aspects of the discipline of creativity is restricted to those aspects, which affects the systematic design process directly.

To determine the context of the research the models of individual problem solving have to be taken into consideration. One of the most determining models [2] describes the knowledge structure of the problem solver. Three levels of knowledge are represented; general knowledge, domain-specific knowledge, and procedural knowledge. Adapting the model to designer's activities the importance of methodological knowledge (i.e. procedural knowledge) is revealed. The other important model has been described by [11]. The model of the Five Steps arranges the solution finding process into external and internal sub-processes. The model, extended by an integration of Guilford's [12] divergent and convergent phases and also indicating the cognitive features of problem solving is eventually able to describe the early stages of the design process from the problem identification to the selection of the best concept from the designer cognition point of view [4]. The research was carried out in desk research and systematic arrangement and evaluation of experiences, as well as testing the developed methods.

2.2 Observations

The steps of design methodology in the early phases track the general model of concept generation (Figure 1). The author states that the model of technical concept generation – with certain supplements – is a possible framework for support in a design process of an arbitrary type and complexity original product. The remarks are summarized below, in the form of definitions.

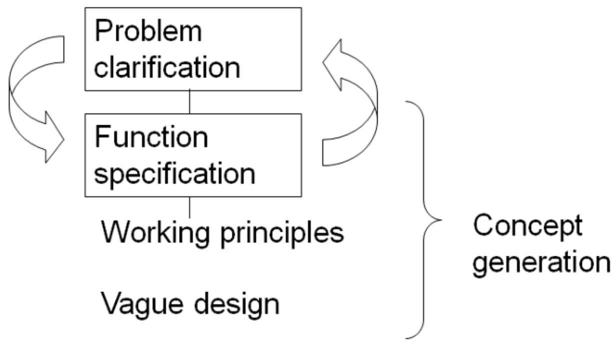

Figure 1: Classic model of concept generation

The step of problem specification aims at identifying the major product advantages or features, which are required or acknowledged by the customers or users (market). This means that the product's functions and the deterministic features have to be matched, which also presumes the integrative approach of marketing thinking and design thinking. This step is successful, if the result could be handled by the designer in the means of complexity and the state of definition, i.e. it is not too complex and relatively well defined. When identifying the solution principles the designer collects those possible solutions, which draws up the solution space (where the principle solutions could be generated). In the principle design step the creation of the applicable geometry is aimed at (generally by sketchy designs), which implies the possibility of objectification of the specified problem.

The observations taken from the literature are affirmed by our experiences, so we are positive that throughout the generation phase of principle solutions the goal is to generate a large number of innovative solutions (in comparison to the specified problem). It is also assumed that the number of innovative concept possibilities could be used as a quality (control) indicator of the process carried out by the designer. The effectiveness of the process is characterized by the time and resources need of the fulfillment of the quality requirements, which is determined by numerous factors. Out of those the contribution of the designer is the only factor to be discussed in this framework, this would be characterized by two dimensions; to what extent the method supports the activity, and the applicability on the individual level. In this aspect the effectiveness is not discussed; though it is assumed that solving major design methodology and psychology challenges in it will lead towards an increase in effectiveness.

In respect of the above mentioned referring to the early phases of the design process the following methodological challenges were identified upon the basis of experience.

2.3 Challenge for innovation in task specification

The initial design problems (input information) are ill defined, the task specification is challenging. Upon the experiences of numerous NPD processes, also by the analyses of existing consumer products it could be drawn that the quality of the design task (marketing concept) significantly determines the innovation content of the future product. The observations are in coincidence with the literature information. If the design problem specification is also a task for the designer (team), a systematic tool would be desirable to support them. The first thing to be identified would be the relation of the available information and the necessary information to be able to formulate the problem specification; numerous methods are available to support that step, e.g. information model technique, search space.

We think that it is possible to create innovative solution possibilities as task specifications on the level of search space of the marketing concept, so the definition of possible innovative solutions on the task level is the task specification for the designer at the same time.

2.4 Challenge for innovation in finding an original solution

To come up with an original solution is difficult and challenging as well. It is indeed hard to abstract from the product category (archetypes exist) and the common characteristics of the classes as well. The reason is on the one hand the psychological inertia, on the other hand the designers approach novelty as something breakthrough, while systematic, incremental innovation tends to be non-existent. This approach fails due to its complexity; the variables are too much to be handled at the same time. For the same reason, the decomposition or break-down of the product by attributes, features is an uncommon method, this might require systematic and abstract thinking as well. It is a determining condition that if the market research, analysis, collecting the needs are parts of the process, the designers tend to be fixated to existing solutions.

We are positive that the basic approach has to be changed; the concept generation phase has to aim at novel, innovative solutions solely, and not at a high quality solution. Alike most creative techniques we recommend that the generated novel solutions are evaluated and confronted to the needs and requirements in the concept development step.

2.5 Challenge for innovation in generating solution variants

The step of generation of solution variants, to develop a high number of solution alternatives is found to be critical and challenging. A number of methods and tools are available for the designer, generally intuitive techniques. The systematic approach is supported by several methods, although these advise generation of solution alternatives for mainly technical, well decomposable problems.

We propose a procedure, which structures the already available ideas and solutions. If we are already aware of the attributes, variables of the given idea, we can utilize those dimensions, change the value, so further alternatives will be possible to be formulated. If we do not know the attributes of the idea, the procedure gives direct support for systematic analysis of the given idea, of which the results will identify the attributes and features, providing a guideline for novel ideas to be deducted.

3 RESULTS, DISCUSSION

3.1 Innovation in task specification

The assignment in our example is ill-defined, so careful specification is needed in the definition phase. The research phase is bi-level in the fuzzy front end [13]; more precisely it consists of a general and a focused research phase in order. The general research could be made systematic with the analysis of the assignment, so the lack of information could be eliminated through an order. In our example the task is the following: to design a skill developing toy for children of kindergarten age. The designer students have the topic for the first time, so definitely the domain specific knowledge will turn out to be insufficient. Note that it does not only mean actual content-type chunks of information, but also the domain-specific internal knowledge is missing. If the designer chooses the keywords represented in the project description (skill, development, skill-development, child, toy, children’s toy, and kindergarten age) for the basis of the information model, the procedure will organize the gained knowledge properly. We propose that the output of the research should definitely be a search space, which reveals the relationship between the major classes and the structured inner content of them, on each and every level and relation. In our example according to the calling words high amount of information was collected and processed from the fields of psychology, pedagogy, developmental psychology, market situation, notions and types of toys, games, and play, age dimension. It is important that the search field has to be a discovery matrix, of which the aim is not to assess the quality, more to provide the possibilities that come off in the intersections of the dimensions. In practice it means that the total combination of the dimension variables describes the search space.

We state that in the case of an ill-defined problem, such as the one in the example, the procedure is applicable for preparing a marketing concept from the organizational point of view, since needs, functions, target groups, etc. come in question. Furthermore the procedure is suitable for the designers as well, enabling them with the option for precision task specification; depending from the number of determining dimensions the search space extends, at the same time – due to the increased number of factors - there will be an opportunity to deal with better periphrased, more specific design tasks. The search method seems effective, because there is a distinction in the procedure between the possibility (solution) generation steps and the selection steps. The solution generation steps could be made systematic, and no quality issues arise. In the selection steps determine the quality, when the marketing concept is being chosen. A further advance of the method is that according to the type (subject) of the design project, it is not necessary to produce the search matrix repeatedly; the matrix could be either updated or extended.

A randomly chosen combination from our example representing all the dimensions with one or two possible variables could be the following: “Aiming at developing the spatial perception, projection perception skills of the 3-4 year old non-handicapped children with normal developmental status with a certain toy, which is either or all a construction toy, role play toy, or a transportation toy”, where any attribute can be switched or changed to another fitting the dimension. Note that certainly the conclusions found throughout the research serves as worthy guidelines selecting the viable direction.

3.2 Innovation in finding an original solution

For the problem that it is challenging to come up with an original solution, the author proposes a similar approach, which is totally different from what the practice shows nowadays. The main point in the approach is that in the case of the original design not an innovative and good (i.e. meeting the quality needs) concept has to be generated, but a novel concept needs to be proposed, which later will be transformed into a good concept. On the level of general problem solving and the level of sub-solutions an approach comes in picture in numerous methods that the step of solution finding and the evaluation of the solution finding step should be separated in time, (e.g. the well-known Brainstorming method of Osborn [14]).

According to the proposed idea, the innovative concept generation must have only one explicit aim, to create novel, innovative ideas, and the first (and primary) evaluation and selection criterion should be the same. It was experienced that the assessment by the criterion of innovativeness has less drawback on the process than by other criteria in immediate judgment. The assignment in our example seems simple; from closer look it is much more complex considering the high number of dimensions determining significant product features, similarly to the high number of variables. We call this a complex, ill-defined task, which can only be handled, if it was successfully specified and narrowed down. It is also a feature of the approach that the quality measurements of the concept alternatives are not left out. In the step of the concept selection the viewpoints of e.g. the desired or required level of innovation, feasibility, etc. market-success, or technical could be taken into consideration.

In this proposed approach the latter viewpoints are no driving forces of the conceptual phase but screening criteria. Designers often follow the way that they intend to come up with an innovative product being novel in all aspects. Mentioning “all aspects” was intentional; it has been observed that the designer tries to break down the problem (sometimes it is necessary due to the cognitive limitations, e.g. Miller’s Magic Number Seven, etc.), and organize it according to “aspects”, etc. We think that an approach fits the mental model of the designer, in which e.g. the existing solutions are studied as they were non-distinguished solutions for the initial problem, but the solution element designates a dimension to seek further solutions in the solution field. Referring back to the problem specification issue, let assume that an elaborate search space exists; it could be utilized as a starting point for novel solutions. In comparison to the search space, the solution space is one dimension deeper.

According to the standpoint of ours the application of the method based on the sketched approach could assist the designer to secede from the product archetypes, also could contribute to take the fixated function-solution relationship into consideration with criticism. In our research a number of examples were seen that after applying the method a certain toy frees of the category’s archetype, the conventional solutions in its theme, geometrical build-up, etc.

3.3 Innovation in generating solution variants

Generating solution variants, large number of alternatives is the last critical step to be discussed. The most methodological school agrees upon that the divergent solution finding step is successful if a large number of ideas, solutions are identified for the problem in hand, this is the so called “quantity breeds quality” thumb rule [14]. As opposed to the terms “idea generation”, “ideation”, commonly used in the design science literature as well, the author insist on using the term “solution finding”. This both reflect the characteristics of the individual problem solving patterns (see: discursive and intuitive), and on the whole fits the features of the sets of solutions in question (see: existing solutions, analogous solutions, novel solutions) better. The solution finding methods are well-known, but literature pays little emphasis on the question of generating solution variants. Though “independent” alternatives are welcome, the generation of “derived” variants is barely supported by tools.

The approach of the method below was originated from the following train of thought. Successful and less successful products were analyzed, and relationships were sought to hypothetically connect the products via a series of imaginary design and decision steps, i.e. what design and decision steps would have to be made to develop one concept from the other. This experiment should exclusively involve solutions provided for the same or almost identical initial problem. It has been experienced that innovation could be observed, analyzed, could be narrowed down to one or more dimensions of the problem, the solution, or the evaluation. The aim of generating a large number of solution variants is traditionally to set up a solution space which potentially includes the finest solution alternative, being selected later on quality criteria. It is also acknowledged and seems obvious that a high degree of creativity is needed for generating solution alternatives, just like for generating the solutions themselves. In fact the systematic preparation of solving the task could guide the designer so close to the solution, which from that point of view the solution might seem trivial. In the further research steps the mentioned experiences are aimed to be used for generating a large number of solution alternatives.

For the problematics of generating solution variants design science as well as psychology has parallelly developed a number of methods, which are partly alternatives, independent from each other on the mode of action, partly synergetic.

The classification of the methods by Tassoul [15]: i) inventorising techniques, ii) associative techniques, iii) intuitive techniques, iv) provocative techniques, v) analytic-systematic techniques.

The inventorising technique (i) is to collect and recall information around an issue, for example a mind map. Associative techniques (ii) usually mean generating large number of ideas in relatively short period of time. Spontaneous reaction to ideas expressed earlier. A classic example is the Brainstorm method. Intuitive techniques (iii) mean guiding idea generation by whatever comes to mind, allowing spontaneous and intuitive idea generation followed by reflecting on the generated ideas.

In the case of the provocative techniques (iv) assumptions and preconceptions are broken from within the familiar frame of reference by making use of analogies, metaphors, random stimuli and provocative questions (‘what if?’ and ‘what else?’, e.g. WWWWH aka Kipling method. Thinking outside one’s frame of reference results in breaking presuppositions. New, unexpected combinations of viewpoints can arise by making new connection (force-fit) between original issue and new idea. A classical example is the Synectics method (first published by Gordon, 1976). Lately two provocative techniques are applied in toy design; *behavior diagram* and *extreme characters*. Both are new behavioral approaches.

„The *behavior diagram* presents the solution space as a diagram with two behavioral dimensions: realistic versus imaginative, and active versus receptive. This diagram can be used as a creative tool by placing an idea for a toy and the envisioned use(s) of the toy within the diagram and then thinking of how the toy could be adapted to facilitate a different behavior style with it. This adapted toy is placed in the diagram and can function as a starting point for a next adaptation, the initial idea being changed again and again to cater for various play types. The variety within the collection of ideas increases, allowing the designer to choose (combinations of) ideas that facilitate potentially interesting behavior.

A second creative technique in use is called ´*extreme characters*´, after a method described by Djajadiningrat, Gaver, and Frens [16]. This technique is especially useful if a student is having difficulties imagining the freedom of behavior within play and sticks to well-known, predictable and all too ´decent´ behavior concepts and toy ideas. For this technique, a diverse selection of well-known archetypical characters are chosen (Spiderman, SpongeBob, James Bond, or non-fictional but clear and extreme characters). Their behavior style is summarized in some keywords. Next, the character is linked to the toy idea and the question is asked: what would this character want to do with this toy? How could this toy be changed to support this behavior better? The exaggerated behavior style of the character makes it easier to break self-imposed limitations on the imagination of children's possible play behavior." [17]

Analytic-systematic techniques (v) give an analytic and systematic description of the problem and its sub-problems, drawing up an inventory of solution variants and systematic varying and combining the solution variants. Examples are Function Analysis and the Morphological Method.

The classic analytic-systematic approach suggests generating solution variants on the level of the Function Structure by making modifications (e.g. removing function, adding function, redrawing the system boundary, etc.). The solution field methods, e.g. the Morphological Matrix Method from Zwicky serves as arranging the functions and the possible solution elements, and to a certain extent inspires to systematically elaborate the solution space. Function Analysis is similarly based on a systematic classification and ordering of the abstract functions. There are also a few elementary thumb-rules available to generate variants from the emerging principle solutions, e.g. changing the physical place of effect, changing in cardinality, etc. [1]. The classic machine design approach supports the design process of the machine-like products, though works in certain cases of non-technical products. Note, that the abstract function oriented approach works for all kinds of products, only the procedure might be too complex and time consuming, so it generally remains a theoretical option, rather than a tool in practice.

The other well-known group of systematic solution finding methods are the TRIZ [18] based approaches, which were originally developed for technical problem solving. Within the theories, methods, and tools there can be found several ones which supports not only technical problem (in the TRIZ terminology: contradictions) solving, but could be successfully applied in design, economy, etc. Those methods can also be considered as psychological, generally provocative class of tools as well. Such approaches are e.g. the Smart Little People, Resources, etc. For generating solution variants for a technical problem the most popular TRIZ methods can also be used, e.g. Inventive Principles, Contradictions, Standard Solutions, etc.

The procedure proposed by the author belongs to the analytic-systematic approaches. The main point is to systematically analyze and structure the already available solution ideas with the purpose that the designer has to be aware of the innovative content and the creative potential of the given idea. The starting point was the observation that designers do not approach the idea (solution) generation in a systematic manner. They understand the conceptual phase as on the basis of the problem specification the basic and most crucial requirements have to be performed, for this purpose some different complex concept alternatives have to be generated, later evaluated. In the case the designer carries out a systematic solution finding process, the proposed procedure still works, and might be adapted to the systematic flow.

The key element in the proposed method is practically a mini-SWOT analysis, which evaluates the solution alternatives from the aspect of innovative content. Accordingly the method was named *I-SWOT* (Innovation SWOT). There has to be two steps distinguished in the method; analysis and solution finding. The process of the analysis begins with the collection of relevant data on the solution alternative. The aim of the analysis is to identify the abstract building blocks, features, ingredients, etc. of the idea, which characteristics are called attributes. The sum of the attributes draws the entire idea in a way that it is possible to be identified and possible to be differentiated. According to the common manner of SWOT analysis the attributes and the short descriptions are put to the quarter-spaces being evaluated by the criterion of innovative content. The attributes in the fields of Strengths and Opportunities would be the strong points from the innovation point of view. The procedure enables the designer to develop a solution space (see problem specification and original solution above) by trying to identify the criteria or dimensions of segmenting the solution space. In the solution generation step the results of the I-SWOT could be applied as provocative elements, as well as the set of values could be systematically tested in the variables. The interim analysis results might reduce development time and might orient the designer. The strengths of the method are the analytic-systematic approach, and that it takes the characteristics of individual creative mind into consideration. The systematic approach does not substitute the creative act; more gives a structure and guidance to it. It provides a provocative environment to the designer and deliberately targets innovation, and gives the management the freedom to set the desired level of innovation in the very early phases.

We are positive that by the analysis of the freely generated and complex ideas certain innovative elements could be extracted from the designer's work, which could serve as an attribute or a combination element, with the development and elaboration of which eventually it will lead to innovative products.

4 CONCLUSIONS

Clarifying and defining the problem in the specification phase, avoiding the fixation of the archetypes and trivial solutions, and generating a large number of ideas in the conceptual phase are found to be critical to be supported. The author suggests systematic approach to the three problems. The results match the individual designers' mental processes, and give prescriptive aid into the practice. Integration in the approach is just as important as the integration in using the different available tools and methods. Although we have positive experiences testing the new approaches, the results require further testing to be scientifically relevant.

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Corresponding author:

Balázs VIDOVICS
Institute of Product Design and Manufacturing,
Faculty of Wood Sciences, University of West Hungary
4, Bajcsy-Zsilinszky u.
H-9400, Sopron, Hungary
e-mail: vidovics.balazs@gt3.bme.hu