Key Research Issues in User Interaction with Configuration Toolkits in a Mass Customization System

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Key Research Issues in User Interaction with Configuration Toolkits in a Mass Customization System: The Foundation of the Idtown User Design Project

Abstract: The idea of integrating users in the design and production process is a promising strategy for companies being forced to react to the growing individualization of demand. While there is a vast managerial literature on mass customization, empirical findings are scarce. Our literature review shows that specifically the core of a mass customization system, the toolkit and the users' interaction with it, is hardly researched. The objective of this paper is to set a research agenda in the field of user interaction with toolkits for mass customization. From the literature and 15 exploratory expert interviews with leading pioneering companies we deploy four key research issues in this evolving field

Keywords: mass customization, configuration, user innovation, customer integration, toolkits, user co-design

1 Introduction

The idea of integrating users in the design and production process is a promising strategy for companies being forced to react to the growing individualization of demand. In the mass customization concept, goods and services are to meet individual customer's needs produced with near mass production efficiency (Tseng and Jiao 2001). While Toffler (1970) had already anticipated the concept three decades ago, Davis coined the term mass customization in 1987. The idea attained wide popularity with Pine's (1993) book.

Mass customization is often connected closely with the capabilities offered by new manufacturing technologies (CIM, flexible manufacturing systems) reducing the trade-off between variety and productivity. But the main distinctive principle of mass customization is a mechanism for interacting with the customer and obtaining specific information in order to define and translate the customer's needs and desires into a concrete product or service specification (Zipkin 2001). In this way, the customer is integrated into the value creation of the supplier. "Consumers take part in activities and processes which used to be seen as the domain of the companies" (Wikström 1996, p. 360). The result is a system of co-production, i.e. a manufacturer-customer interaction and adaptation for the purpose of attaining added value (Milgrom and Roberts 1990; Normann and Ramirez 1994). The customer becomes a "co-producer" respectively "prosumer" (Toffler 1970). While this view is not new (see Ramirez 1999 for an overview), it is only today that we see a broader application of this principle in practice (in business-to-consumer as well as in business-to-business markets). However, as the main part of the interaction with the customer takes place during the configuration and therefore the design of a customer specific product, it seems appropriate to call the customer rather a co-*designer* than a co-producer. Customer co-design describes a process that allows customers to express their product requirements and carry out product realization processes by mapping the requirements into the physical domain of the product (Helander / Khalid, 1999, Tseng/Du 1998, von Hippel 1998). During these co-designing processes, users sometimes even take over the role of being the innovators: the "need-information" is converted into a solution at the locus of the user without costly shifts of the information from user to the manufacturer (von Hippel 2001). Against this background, the importance of an interaction and configuration toolkit that enables users to design the product desired seems obvious.

The objective of this paper is to review the present research on configuration toolkits for mass customization in order to set an agenda for future work. To provide a background, in section 2 we theoretically analyze the mass customization system and find support for our conjunction that toolkits constitute a research field of supreme importance for the understanding of success and failure of mass customization applications. We review empirical studies on mass customization and find, on the contrary, that little knowledge on the use of

and the interaction with toolkits exists. We then identify four key research issues on the users' interaction with these toolkits (section 3). The paper concludes with the outline of an empirical research design to address these questions.

Our analysis and conclusions are not only based on literature. The field of user integration and mass customization is evolving so rapidly that we found it important to include the knowledge from industry experts as well. Therefore, we conducted a series of interviews with experts from pioneering companies of mass customization (see table 1 for an overview). We concentrated on firms that are reported to exhibit "best practice" within their industry or are often quoted as a leading example, or to choose companies that have been carrying out mass customization operations for a longer period of time. For each case, we interviewed managers in charge of the customization program (which was often the CEO), and, if available, the manager in charge of the web site and customer interaction or customer service. The interviews were semi-structured and conducted in most cases face-to-face (otherwise by telephone) between January 2001 and April 2002.[1]

<<< Insert table 1 about here >>>

2 Literature Review: Research on Mass Customization

2.1 The Importance of Toolkits for a Mass Customization System

The integration of the customer creates a collaboration between the supplier and the customer which supersedes the traditional value chain. Companies successfully pursuing mass customization build an integrated knowledge flow – that not only covers one transaction but uses information gathered during the fulfillment of a customer-specific order to improve the knowledge base of the whole company (Gilmore/Pine 2000; Piller 2001; Zipkin 2001). During the whole process the interface between manufacturer and customer is crucial. Not only does it comprise the solution space of the production facilities, but it is also the design instrument both for new and existing customers, the core communication tool, and supposed to be the main origin of customer loyalty (e.g., Pine/Peppers/Rogers 1995; Riemer / Totz 2001; Vandermerwe 2000). This mechanism was mentioned in most of our interviews as being a premier success factor of mass customization, even if almost half of the interviewees admitted that their implemented system does not fulfill this task properly.

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[1] This approach of qualitative research is consistent with the "laddering approach" (Durgee 1986) and the "narrative approach" (Mishler 1986) advocated by other qualitative researchers (Homburg et al. 2000). From the field research, we tried to identify important key factors through an iterative process like recommended by a number of qualitative researchers (e.g. Drumwright 1994; Workman et al. 1998).

Additionally, the interaction system is the prime instrument for reducing the user's costs arising from a principal-agent constellation that is inevitable in mass customization. From the customer's perspective the co-design is connected with additional costs (Huffman/Kahn 1998; Gilmore/Pine 2000). Users often have no clear knowledge of what solution might correspond to their needs, sometimes they still have to find out what their needs are. As a result, customers may experience uncertainty during the design process. Uncertainty about the behavior of the supplier exists, too. The newer and more complex the individualization possibilities are, the more information gaps increase. These processes are characterized by an asymmetrical distribution of information – a typical principal agent constellation (Fama/Jensen 1983): A customer (principal) orders from the supplier (agent) – and often pays in advance – for a product she can only evaluate in a virtual form and has to wait days or even weeks to receive it. These uncertainties can be interpreted as additional transaction costs of a customer arising from individualization. One of the most important tasks of the supplier is to ensure that the customer's expenditure is kept as low as possible, while the benefit she experiences has to be clearly perceptible.

Interaction systems for mass customization are the premier instrument to reduce these costs. Known as configurators, choice boards, design systems, toolkits, or co-design-platforms, these systems are responsible for guiding the user through the configuration process. Different variations are represented, visualized, assessed and priced which starts a learning-by-doing process for the user. While the term "configurator" or "configuration system" is quoted rather often in literature, it is used for the most part in a technical sense addressing a software tool. The success of such an interaction system is, however, by no means not only defined by its technological capabilities, but also by its integration in the whole sale environment, its ability to allow for learning by doing, to provide experience and process satisfaction, and its integration into the brand concept. Tools for user integration in a mass customization system have to contain much more than arithmetic algorithms to combine modular components. Using an expression from von Hippel (2001), we will therefore use the term "toolkit" in the following.

While toolkits theoretically do not have to be based on software, all known mass customizers are using a system which is at least to some extent IT based, Despite a huge variation, mass customization toolkits consist of three main components (Bourke 2000; Weston 1997; Piller 2001):

- The core *configuration software* presents the possible variations, and guides the user through the configuration process, asking questions or providing design options. Consistency and manufacturability are also checked at this stage.
- A *feedback tool* is responsible for presenting the configuration. Feedback information for a design variant can be given as a visualization and in other forms (e.g. price

information, functionality test etc.) and is the basis for the trial-and error learning of the user.

- *Analyzing tools* finally translate a customer specific order into lists of material, construction plans, and work schedules. They further transmit the configuration to manufacturing or other departments.

There is a broad spectrum of toolkits for customer driven product development and configuration. On one end the continuum there are simple toolkits where users are just allowed to choose from different options (color, size, etc.) – a good example is Dell Computers. In such systems, the degree of innovativeness possible is rather limited. On the other end of the scale, there are toolkits that assign the user a much more active role. Here, the user actually *creates* (and not chooses) which allows for radical innovations. An example for these more extreme toolkits is open source software where the users are (almost) free to program whatever comes to their mind. But although toolkits thus can be quite heterogeneous: the user's interaction with it is of premier importance for the success of the respective user integration system.

2.2 Empirical Work in the Field of Mass Customization

In 1996 Lampel/Mintzberg (1996) had already identified more than 2000 articles written on Mass Customization. A recent exploratory study by the authors of this paper in two bibliographic databases leads to more than 3500 articles on the subject. Although both figures are probably misleading since they include many articles from non-scientific sources, they indicate the growing amount of research in the field. But surprisingly, many authors tend to build their work on rather shallow case studies or fail to include any empirical research at all. Here, a large research deficit emerges. Table 2 lists the extant ("serious") empirical work the authors could identify in the field of mass customization.

The empirical research can be differentiated into three clusters: The first and largest group is formed by work structuring the field of mass customization and customer interaction in general (Ahlström/Westbrook 1999, Duray et al. 2000, Feitzinger/Lee 1999, Franke/Mertens 2001, Kotha 1996, MacCarthy/Bramham/Brabazon 2002, Piller 2001, Piller/Schoder 1999, Strauss/Schoder 2000, Vickery/Droge/Germain 1999; for more literature see Da Silveira / Borenstein / Fogliatto 2001; Piller 2001; Tseng/Jiao 2001). Typical research questions are the state of art within different branches of industry, structural approaches of mass customization, and the identification of best practices. This work is driven by the objective to show that mass customization is a specific form of value creation and to illustrate how it differs from (craft) customization and mass production.

The second group is related to specific questions of customer (user) driven innovation (Franke/von Hippel 2002, Gruner/Homburg 2000, Thomke/von Hippel 2002, von Hippel 1998 and 2001). Here, in the focus of the research is not to customize goods or services, but to

integrate customers or users into new product development. The objective of the studies in this group is to analyze how user driven innovation works, how users perform their innovating activities (by the means of innovation toolkits), and what success can be achieved.

A third, rather small group of research tries to understand personalization, customization and customer integration from the perspective of the customer or user (Bauer/Grether/Leach 1999, Dellaerta et al. 2001, Huffman/Kahn 1998, Khalid/Helander 2001, Meuter et al. 2000, Ng 2000, Oon /Khalid 2001). The basic research questions are how consumers handle choice and experience the integration into configuration, and what are the factors of (customer) satisfaction which are related to customization. Additional, explicitly methodological work comes from Liechty/Ramaswamy/Cohen (2001) and Tian / Bearden / Hunter (2001). We will discuss these findings together with other methodological issues later in this paper.

<<< Insert Table 2 about here >>>

While the papers presented in table 2 are strongly differentiated with regard to their methodology, research field, focus, and even their findings, they all stress the importance of the toolkit for customer interaction. Configuration tools are identified by the studies of the first group as a distinguished part of mass customization systems, being an important enabler of the cost position of mass customization. Similarly, the papers of the second group are based on the fact that technology enables the use of toolkits for user innovation without high transaction costs. However, the papers of groups 1 and 2 just state the importance of an interaction tool and discuss some of their generic characteristics, but do not provided insight into how users interact with these tools, and how the design of a toolkit influences purchasing decisions and customer satisfaction. This is the focus of the researchers of the third group. But despite a few exceptions which will be discussed in further detail in the next section, the studies do not address the characteristics of toolkits in mass customization environments in particular.

Thus, while the transfer of the findings of other areas of customer interaction to mass customization provides some interesting insight, we feel that there is the need for more specific research. While there is plenty of research on the design of retail stores, shop layouts and retailing environments, there is practically no comparable (user directed) research on the design of mass customization toolkits. The transfer of studies of web sites for online selling is difficult as traditional online shops are much more related to print catalogs than to a modern toolkit for customer interaction in a mass customization environment. In conclusion we state that there is an immense gap between the canonical importance of configuration toolkits and the state of the art regarding the empirical findings. As mentioned above, our exploratory interviews confirmed this gap as well for acting mass customizers.

3 Key Research Issues on Toolkits for Mass Customization

From both our exploratory interviews and the literature review, four key issues appear of supreme importance for the development of our understanding of the phenomenon of mass customization:

- Process pattern of user interaction: How do users interact on a mass customization web site?
- Reception of complexity: Does "mass confusion" exist?
- What drives user satisfaction concerning toolkits?
- Value of individualization: Does mass customization pay?

This chapter will briefly explain these key issues, review the related literature, present reasons why empirical insights in these questions are important and discuss what kind of empirical information appears pertinent in the light of the status quo of the literature. We will focus our discussion in the following on mass customization systems that are Internet based, and thus on toolkits for mass customization that are integrated within a web site. While mass customization is not connected per-se with electronic business, its growth is related widely with the upcoming Internet economy. The use of the Internet as a communication medium facilitates the efficient production of customized goods as well as the personalization of customer relationships (Duray et al. 2000; Lee / Barua / Whinston 2000).

3.1 Process Pattern of User Interaction

As already discussed, the configuration toolkit takes the role of the central interface between the mass customization company and the customer. All other points of contact like shipping, the product itself, and the company's reaction to possible complaints occur later – or do not occur at all if the interaction with the tool was so unpleasant that the user terminated the design process. But it's not only that user satisfaction with the toolkits is critical for the success of mass customization applications – toolkits are also costly to develop, implement, operate, and change (Investments for recent web based toolkits for mass customization start at 100,000 US$, and most companies have invested at least ten times this sum, according to our exploratory survey). Hence, the programming of such a tool is both a risky and important investment for a mass customization company.

One would expect a rich research literature and ample empirical insights in this apparently important issue. There is a fair amount of literature on technical aspects of product configurators and how to integrate them with the other elements of a mass customization system (e.g. Bourke 2000; Weston 1997). But out of our literature review we could hardly identify any empirical analysis on the actual interaction patterns of customers with toolkits for mass customization. Thus, before turning to specific topics such as the reception of complexity, determinants of satisfaction, and economic consequences of the interaction we

have to gain an understanding of how users actually interact with extant mass customization configurators, i.e. how they proceed while designing a product and which patterns are visible in the discovery of one's own needs (Park et al. 1994; Stabell/Fjedlstadt 1998). From our exploratory interviews we received the impression that very crucial decisions regarding the design of the configuration toolkit are often based on relatively simple rules of thumb that were never tested empirically. It seems that there is little knowledge on user interaction patterns with toolkits for mass customization not only in research but also among practitioners.

In the following we therefore consider what insights related research areas offer. Research into user interaction with *data bases* (e.g. Canter/Rivers/Storrs 1985) and *web sites* resp. the *Internet* in general (e.g. Chen/Rada 1996, Nielsen 1995) provides only limited insights. Naturally, rules such as "make the site structure easily understandable" or "avoid long downloading time" (e.g. Nielsen 2001, Vora 1998) that are deduced from such research also apply to mass customization toolkits as they are normally integrated into web sites. But the task of actively designing a product goes far beyond usual browsing behavior.

Studies in innovation processes might reveal more insights. Also in a mass customization system, the customer takes the role of a co-innovator. Thus, it might be helpful to study how innovations, specifically user innovation processes are conducted. For example, it is often found that novel products are developed by 'learning by doing' processes (von Hippel / Tyre 1995, Thomke/von Hippel/Franke 1998) resp. 'trial and error' processes (Ishii/Takaya 1992, Polley/Van de Ven 1996). The underlying rationale is that it is difficult or even impossible to know what one wants at the outset. Therefore, a targeted design process is very unlikely when the outcome has innovative characteristics. The innovator has to learn what is possible, try different possibilities, learn from errors, compare different solutions, and thus conduct a time consuming, iterative learning process. Von Hippel (2001) therefore strongly recommends the implementation of immediate feedback tools for mass customization toolkits.

In conclusion we suggest that studies on the actual design behavior of mass customization users are decisive. So far and somewhat surprisingly this important task is still a black box. We have to gain answers to questions such as

- Do users follow specific patterns while interacting on a mass customization web site?
- How many variants are explored and changed before making a final decision?
- Do individual users have distinct "styles" in customizing products?
- Can we observe "learning effects" of users interacting on a mass customization web site during the course of configuration?

- Do users have a relatively clear perception of the intended outcome of the design process? How "targeted" as opposed to a pure trial and error procedure is the design process?
- In how far are these findings impacted by different user types (e.g. lead user vs. average user) and toolkits types (e.g. simple choice board vs. toolkits allowing for radical innovations)?

3.2 Reception of Complexity: Does "Mass Confusion" Exist?

While mass customization is often addressed in the literature as a promising and beneficial approach to meet today's market demands, some authors have recently discussed its limits and concerns (e.g., Agrawal / Kumaresh / Mercer 2001; Zipkin 2001). One limit of mass customization often quoted is that excess variety may result in an external complexity that Pine termed as "mass confusion" (in: Teresko 1994). Customers can be overwhelmed by the number of choices during product configuration (Friesen 2001; Huffman / Kahn 1998). Large assortments and choice are often supposed to be perceived as negative by consumers. Instead of offering possibilities and choice, they seem monumental and frustrating.[2] Everyone who has experienced decision situations in the face of numerous choice possibilities – e.g. in a super market in a foreign country trying to figure out which of the 200 detergents to choose or in a restaurant facing a menu with 500 meals – knows that to equate a high number of possibilities with high customer satisfaction would be starry-eyed optimism.

The number of choices on typical mass customization sites exceeds these well-known decision problems by far. In fact, one has to convert the choice numbers into a familiar area to get an adequate understanding of *how* many choices the customer has. For example, if all the possible variations of Idtown.com watches, one of our interviewees, (circa $2*10^{11}$) were displayed in a shop, this shop would need to be the size of Luxembourg. If one wanted to build a shop large enough to display all variants of Customatix.com sport shoes (circa $3*10^{21}$) the surface of the whole earth would be scarce – in fact one would need 7,000 planets of the size of the earth, each completely covered with a shop. Toolkits allowing for innovation offer yet endless possibilities. This shows that the premonitions mentioned above are justified beyond question. The burden of choice may simply lead to information overload (Maes 1994; Neumann 1955), resulting from the limitations of the human capacity to process information (Miller 1956).

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[2] It has been found that in some cases very large assortments may make consumers more promotion sensitive than they might be when faced with smaller assortments. Possibly this is because the promotion information is used to screen out unacceptable alternatives from the large assortment into smaller manageable consideration sets (Kahn 1998; Miller 1956).

In the field of mass customization, there is only one empirical study that addresses these points directly. Huffman and Kahn (1998) conducted two surveys with 60-80 participants each on the customization of a sofa and a hotel package, respectively. They used an experiential research setting and asked students of a marketing class to evaluate the two product configurators. An important finding is that satisfaction with the configuration processes is related to the degree of user input in an inverted u-shaped pattern. This means that there is a point of "mass confusion" after a specific degree of variety, but also, that variety has to have some extent to address the needs of a mass customization customer. Huffman and Kahn state that attribute based presentation is preferred to alternative based presentation of customization items. This finding also is an indicator of "mass confusion": Users tend to prefer not to choose from a long list of options for a customization possibility but rather express a need or preference. A fitting option should be then determined automatically by the configurator. While Huffman and Kahn (1998) provide some early and important insight, their research is limited by the fact that subjects were not in a real-life purchasing decision and thus did not have to bear the consequences from their decision, resulting in possibly biased data. Also, the research was not done with a modern web based toolkit, resulting in a limited comparability with today's advanced toolkits.

Research in user innovation (von Hippel 1988), on the other hand, has shown that despite large assortments and the great variety of offerings in most product fields users are often dissatisfied with existing products and often take over the task of innovating. Originally focusing on industrial markets, recent studies demonstrated that this pattern also holds for consumer markets. Among end-users, too, there is a high rate of innovative activities (Shah 2000, Lüthje 2002, Franke/Shah 2002). For example, Lüthje (2002) found that in a representative sample of outdoor athletes, ten percent built a prototype of new sport equipment. Franke/Shah (2002) found even higher proportions of innovators in four samples of snowboarders, canyonists, handicapped cyclists, and sailplaners. The manufacturer-active and customer-passive paradigm (von Hippel 1978) that has been dominating consumer marketing for decades seems no longer consistent with these findings. Of course not all consumers in all product categories are willing to play such an active role. The proportions found by Lüthje (2002) and Franke/Shah (2002), however, are notably high, suggesting that at least a large minority of consumers in every product field is likely to be eager to gain more choices and a more active role in the design of products – thus acclaiming the offering of mass customization. It might even be that the variety of choices of typical mass customization configurators is considered too low by some users. As we depicted, permutations of choice options quickly reach an immense number of possible products. But to some degree, these numbers are misleading. Notwithstanding the seemingly endless options, the role of the user in most cases is still rather passive: she is just enabled to (passively) *choose* from lists, not to (actively) *create* as von Hippel (2001) suggests in his conceptual analysis of toolkits for user

innovation. Of course active creation would augment the levels of complexity and user endeavor required.

To conclude, we have to state that there is almost no empirical insight on how customers actually respond to the complexity created by mass customization toolkits.

Hence, we have to gain answers to questions such as

- Do users feel overloaded by the information on mass customization sites?
- What is an appropriate number of choices from the user's perceptive?
- Do different process designs and experiences of toolkits make it possible to handle different degrees of variety from the user's perceptive?
- To what extent is the role of a more active designer rather than a more passive chooser desirable?
- Are there great differences between different customer groups? Which factors cause these differences?

3.3 User Satisfaction: What Drives User Satisfaction with a Toolkit?

Both of the preceding research issues we discussed earlier lead to the same question: How satisfied are users of mass customization toolkits and what are the drivers of their satisfaction? The importance of this question is evident. Supposedly, only users who have a particular minimum level of satisfaction with the toolkit will finalize the design process and purchase the product, recommend the site to their acquaintances, and come back themselves – always assuming that the satisfaction with the product designed is sufficiently high. Research in customer satisfaction confirms the importance of this construct (Johnson/Gustafsson 2000). It also seems conceivable that the satisfaction with the process has a large impact upon the satisfaction with the product in mass customization (Riemer/Totz 2001). First, it has been shown that the perception of product quality and that of a retail outlet are closely related (Anderson/Sullivan 1993, Patterson/Johnson/Spreng 1997). Manufacturers therefore often strive for shelf-space in high-level outlets. In a mass customization system, the physical store is replaced by the toolkit. It has to deliver experience and meet the high customer expectations connected with customization. This goes hand in hand with the demand for a steady quality of service. Companies have to implement strong instruments to build trust and reliability in order to reduce the risk seen by prospective customers in an individualization process. Secondly, and even more important is the fact that in mass customization the individual product is the *direct result* of the process. A mass customizer is offering a solution capability, not a product. A felicitous and successful process will therefore have an impact on both process *and* product satisfaction.

Few studies exist that tackle this important area in the domain of mass customization. Totz and Riemer (2001) deliver an extensive contingency model but do not offer any empirical insights so far. Some evidence is given by Oon and Khalid (2001). In two small surveys they compare the perception of three mass customization web sites. For this, they measure user satisfaction of different aspects of configuration toolkits (such as like quality of guidelines, number of choices etc.). However, they hardly offer any explanation as to which factors cause different satisfaction levels or data on the relative importance of the aspects investigated. Bauer/Grether/Leach (1999) survey the relationship between user satisfaction and customization on the Internet quite generally and find a positive correlation. However, their research is based on interviews with managers about the perception of satisfaction of their customers, and thus only offers indirect insights.

Recently, the flow construct (Csikszentmihalyi 1977, 1990) has been discussed as a useful variable for understanding consumer behavior on the World Wide Web (Novak/Hoffman/Yung 2000, Bauer/Grether/Borrmann 2001). Flow, defined as the sum of skill and challenge experienced is found to be positively related to users' online search and purchasing activities. It seems plausible that taken as a moderator variable between the individual user's or resp. the toolkit's characteristics and user satisfaction, it will offer fruitful insights. The peculiarities of user design with a mass customization toolkit as compared to "normal" browsing and even online purchasing behavior, however, limit a direct transmission of the findings. Empirical insights in this matter are therefore prerequisite.

According to the available literature mentioned above, we hypothesize that personal characteristics such as creativity, innovativeness, need for individuality have an impact upon the experience of flow and user satisfaction with a toolkits. To conclude we suggest that research on process and product satisfaction, flow experience, their interrelation, determinants and consequences regarding mass customization toolkits is a key issue in the advancement of our understanding of the phenomenon in question.

Future projects should tackle questions such as

- Which factors cause user satisfaction with toolkits for mass customization?
- What is the interrelation between process and product satisfaction?
- Which user characteristics cause the satisfaction differences likely to be observed?
- Which usability characteristics of a toolkit cause the satisfaction differences likely to be observed?

3.4 Value of Individualization: Does Mass Customization Pay?

For users, the decision to buy individualized products is basically the result of a simple economic equation: if the (expected) returns exceed the (expected) costs the likelihood that she employs mass customization will increase. Costs are, for example, the price of the product

(resp. the price premium if the individualized product has a higher price than a standard offering) and the drawbacks of the user's integration into value creation during the configuration process we discussed earlier (such as risk, information overload, time and effort required, demand for trust, delivery time etc.). Returns are twofold: firstly possible rewards from the design process such as flow experience or satisfaction with the fulfillment of a co-design task, and secondly the value of customization, i.e. the increment of utility a customer gains from a product that fits better to her needs than the best standard product attainable (Chamberlin 1962; Du/Tseng 1999).[3] As the latter might be more enduring, this points to the utmost significance of the *value of individualization*.[4] Only if users value this increment of utility highly enough, they are likely to design their own products via mass customization sites and may be willing to pay a price premium. Our exploratory interviews let us presume that consumers are indeed willing to pay price premiums for individualized solutions. This important hypothesis, however, needs to be tested in large-scale research.

From a manufacturers point of view price premiums are not the only motive to employ mass customization solutions. The chance for sustainable differentiation from its competitors is also of high importance. Today's market heterogeneity, increasing variety, steadily declining product life cycles, decreasing customer loyalty, and the escalating price competition in many branches of industry are the main motivators for firms going into mass customization (Pine 1993). Thus, the sheer willingness of consumers to interact within a mass customization system and to try a toolkit for mass customization is obligatory. In other words: mass customization will be a perpetual phenomenon only if, respectively only in markets where the value of individualization exceeds a minimum level.[5] To our knowledge hardly any attempt exists to explicitly measure (i.e. quantify in economic terms) the users' need for individualization or to quantify the value of customization from a user's perspective. In a recent study, Franke and von Hippel (2002) show that users' needs for security in the field of web server software is highly heterogeneous, suggesting that individualized solutions (like open source software which offers virtually unlimited individualization) can be interpreted as

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[3] This benefit can be differentiated into customization in regard to exact fit (e.g., measurements of a product), functionality (e.g., a customized interface or technological feature), and (aesthetic) design or taste (e.g., custom colors or patterns).

[4] Specifically in the consumer goods field it is of high importance to distinguish between objective and subjective individualization. It might in some instances be the case that the process of designing and thus the "pride of authorship" creates the value for the customer and not so much the "real" individuality of the product per se. One manager in our exploratory study attributed the success of the market introduction of Dell Computers partly to the satisfaction of customers feeling "smarter" than their counterparts (co-workers, neighbors, relatives) when they finished their configuration job and realized that they were able to co-design a computer.

[5] Dewan / Jing / Seidmann (2000) develop a theoretical framework to evaluate the optimal extent of „customization" with regard to possible pricing premiums. While the authors can show within their approach that sellers tend to „over-customize" despite the detriment to their profits (in the case of competing sellers in a mass customization market), the authors fail to address this question with real data and do not take any of the effects on consumer buying behavior into account.

a market reaction to the high value of individualization in this field (and unfulfilled needs by standard products).

In conclusion, we state that research on the economic value of getting an individualized product or service is an issue of vital importance. Only if enough customers value the advantages of customization highly enough is mass customization likely to become a mass phenomenon, too. Thus, research is needed to tackle questions such as

- How highly do actual and potential customers value individualization?
- Which factors have an impact on this valuation?
- What options of customization (fit, functionality, design) are valued most and in which context?
- Are customized products objectively or merely subjectively individual?
- In how far are these findings impacted by different user and toolkits types?

4 Perspectives for further research

In this paper we explored the research field of mass customization. Focusing on toolkits for integrating the user into the design process, we identified four key research issues. The obvious next step would be to conduct empirical research to provide answers to these questions. How can such projects look like?

We propose to concentrate primarily on actual interaction behavior of users with a specific mass customization site. Information should be *observed* rather than asked as much as possible (particularly regarding behavior as e.g. process and design patterns). The reason for this is that we cannot expect much reflection and awareness regarding such processes – the information is "tacit" (Polanyi 1958/1974). Accordingly, to rely (only) on self-reported behavior is open to biases, errors and wild guesses.

To address these questions empirically in the field of web based toolkits, a premier source of information should be log file data. Log files are the protocols of a specific user's activities on a web site. It usually contains information such as the IP-address, the URL of all pages actually requested, detailed information on time spent on a page, and documentation of other actions. Accordingly, we asked several leading mass customization firms in our exploratory interviews for access to their log files. Our only concern was that this information is likely to be of critical importance to the firm which might deter them from externalizing these protocols. After all, the literature on mass customization frequently emphasizes the potential value of permanent learning from user behavior (e.g., Kotha 1996; Piller/Schaller/Reichwald 2002). To our surprise, according to the companies we directly asked, non-disclosure is not the problem – but these log file protocols simply do not exist! Many web based configuration

toolkits are coded in “Flash”, a programming language, and this particular software does not create log files easily.

But even if log files existed: For technical reasons they allow only limited insights into user interaction. Proxy servers and browser caches are a common means of reducing the amount of data transfer by buffering files already requested in a cache – thus if a user requests a file several times or hits the “back” button, the log file registers only one request. It is obvious that this leads to incomplete data protocols. “Spy programs”, installed on the PC of the respective user, deliver a possibility to this problem: They track each command of a user (and thus of the individual design process), the time etc. and work hidden in the background. Only users with exceptionally good knowledge of software are able to detect it.

Other issues can only be tackled by employing questionnaires, such as judgments, mental states etc. The solution to deliver a user who just finished a design process on a specific mass customization website an online questionnaire seems obvious (e.g. via pop-up windows). The problem is that response rates are usually very low which might result in serious biases.

Concluding, we propose that it makes sense to analyze user interaction with mass customization toolkits in a controlled, experimental situation. A sample of users can be invited to design a product on PCs which are prepared with a spy program. Directly after the design process an (online) questionnaire is handed to them. It seems reasonable to conceal or at least not fully reveal the specific method of the study in order to avoid biases – as long as ethical standards are not violated (i.e. the respondents are harmed in any way). Results will increase our understanding of the fascinating and important phenomenon of mass customization and user design. Obviously, such insights are of practical value for this evolving field, too.

References

[1] Agrawal, M., Kumaresh, T.V. and Mercer, G.A. (2001) ‘The False Promise of Mass Customization’, *The McKinsey Quarterly*, Vol. 38, No. 3, pp. 62-71.

[2] Ahlström, P. and Westbrook, R. (1999) ‘Implications of mass customization for operations management: an exploratory survey’, *International Journal of Operations & Production Management*, Vol. 19, pp. 262-274.

[3] Anderson, E. and Sullivan, M. (1993) ‘The Accedents and Consequences of Customer Saticfaction for Firms’, *Marketing Science*, Vol. 12, pp. 125-143.

[4] Bauer, H.H., Grether, M. and Borrmann, U. (2001) ‘Die Erklärung des Nutzerverhaltens in elektronischen Medien mit Hilfe der Flow-Theorie’, *Marketing ZFP*, Vol. 23, pp. 17-30.

[5] Bauer, H.H., Grether, M. and Leach, M. (1999) 'Relationship Marketing im Internet', *Jahr-buch der Absatz- und Verbrauchsforschung*, Vol. 45, pp. 284-301.

[6] Bawa, K., Landwehr, J.T. and Krishna, A. (1989) 'Consumer Response to Retailers' Marketing Environments', *Journal of Retailing*, Vol. 65, pp. 471-495.

[7] Bourke, R. (2000) 'Product Configurators: Key Enabler for Mass Customization - An Overview', *Midrange Enterprise*, August 2000.

[8] Canter, D., Rivers, R. and Storrs, G. (1985) 'Characterizing User Navigation through Complex Data Structures, Behavior and Information', *Technology*, Vol. 24, pp. 93-102.

[9] Chamberlin, E.H. (1962) *The Theory of Monopolistic Competition*, 8. ed., Cambridge: Harvard University Press.

[10] Chen, C. and Rada, R. (1996) 'Interacting with Hypertext: A Meta-Analysis of Experimental Studies', *Human Computer Interaction*, Vol. 11, pp. 125-156.

[11] Csikszentmihalyi, M. (1977) *Beyond Boredom and Anxiety*, San Francisco: Jossey-Bass.

[12] Csikszentmihalyi, M. (1990) *Flow: The Psychology of Optimal Experience*, New York: Harper & Row.

[13] Da Silveira, G., Borenstein, D., Fogliatto, F.S. (2001) 'Mass Customization: Literature Review and Research Directions', *Int. Journal of Production Economics*, Vol. 72, pp. 1-13.

[14] Dellaert, B.G. (2001) *Using Conjoint Choice Experiments to Model Consumer Choices of Product Component Packages*, Working Paper, Department of Marketing, Tilbourg University.

[15] Dewan, R., Jing, B. and Seidmann, A. (2000) 'Adoption of Internet-based product customization and pricing strategies', *Journal of Management Information Systems*, Vol. 17, No. 2, pp. 9-28.

[16] Drumwright, M. (1994) 'Socially responsible organization buying', *Journal of Marketing*, Vol. 58, pp. 1-19.

[17] Du, X. and Tseng, M.M. (1999) 'Characterizing Customer Value for Product Customization', *Proceedings of the 1999 ASME Design Engineering Technical Conference*, Las Vegas.

[18] Duray, R. et al. (2000) 'Approaches to Mass Customization: Configurations and Empirical Validation', *Journal of Operations Managements*, Vol. 18, pp. 605-625.

[19] Fama, E.F. and Jensen, M.C. (1983) 'Separation of ownership and control', *Journal of Law and Economics*, Vol. 26, pp. 301-25.

[20] Feitzinger, E. and Lee, H. (1997) 'Mass Customization at Hewlett-Packard: the Power of Postponement', *Harvard Business Review*, Vol. 75, No. 1, pp. 116-121.

[21] Franke, N. and Shah, S. (2002) 'How Communities Support Innovative Activities: An Exploration of Assistance and Sharing Among End-Users', *Research Policy* (forthcoming).

[22] Franke, N. and von Hippel, E. (2002) *Satisfying Heterogeneous User Needs via Innovation Toolkits: The Case of Apache Security Software*, *Research Policy* (forthcoming).

[23] Franke, T. and Mertens, P. (2001) 'User Modeling and Personalization - Some Experiences in German Industry and Public Administration', in M.M. Tseng and F.T. Piller (Eds.) *Proceedings of the World Congress on Mass Customization and Personalization MCPC 2001*, Hong Kong.

[24] Friesen, G.B. (2001) 'Co-creation: When 1 and 1 make 11', *Consulting to Management*, Vol. 12, No. 1, pp. 28-31.

[25] Gilmore, J.H. and Pine, B.J. (2000) 'Customization That Counts', in J.H. Gilmore and B.J. Pine (Eds.) *Markets of One*, Boston: Harvard Business School Press, pp. vii-xxv.

[26] Gruner, K. and Homburg, C. (2000) 'Does customer interaction enhance new product success?', *Journal of Business Research*, Vol. 49, pp. 1-14.

[27] Helander, M. and Khalid, H. (1999) 'Customer Needs in Web-Based Do-It-Yourself Product Design', in J. Abeysekera et al. (Eds.) *Proceedings of the 10th Anniversary of M.Sc. Ergonomics International Conference*, Lulea, Sweden, pp. 9-14.

[28] Huffman, C. and Kahn, B. (1998) 'Variety for Sale: Mass Customization or Mass Confusion', *Journal of Retailing*, Vol. 74, pp. 491-513.

[29] Ishii, K. and Takaya, I. (1992) 'A Process Design Approach Based on the Fusion Model', *Technovation*, Vol. 12, pp. 499-508.

[30] Johnson, C (1998) 'On the problems of validating DesktopVR', in H. Johnson, L. Nigay and C. Roast (Eds.) *People and Computers XIII*, London: Springer, pp. 327-338.

[31] Johnson, M.D. and Gustafsson, A. (2000) *Improving customer satisfaction, loyalty, and profit: an integrated measurement and management system*, San Francisco: Jossey-Bass.

[32] Kahn, B.E. (1998) 'Dynamic Relationships with Customers: High-Variety Strategies', *Journal of the Academy of Marketing Science*, Vol. 26, Winter, pp. 45-53.

[33] Khalid, H.M. and Helander, MG. (2001) 'Facilitating Mass Customization and Web-based Do-It-Yourself Product Design', in M.M. Tseng and F.T. Piller (Eds.) *Proceedings of the World Congress on Mass Customization and Personalization MCPC 2001*, Hong Kong.

[34] Kotha, S. (1996) 'From Mass Production to Mass Customization: The Case of the National Industrial Bicycle Company of Japan', *European Management Journal*, Vol. 14, pp. 442-450.

[35] Lampel, J. and Mintzberg, H. (1996) 'Customizing Customization', *Sloan Management Review*, Vol. 37, pp. 21-30.

[36] Leavitt, C. and Walton, J. R. (1988) *Openness of Information Processing as a Moderator of Message Effekts on Behavior*, Faculty Working Paper, College of Business of Administration, Ohio State University.

[37] Lee, C.-H., Barua, A. and Whinston, A. (2000) 'The Complementarity of Mass Customization and Electronic Commerce', *Economics of Innovation & New Technology*, Vol. 9, pp. 81-110.

[38] Liechty, J., Ramaswamy, V. and Cohen, S. H. (2001) 'Choice Menus for Mass Customization', *Journal of Marketing Research*, Vol. 39, pp. 183-196.

[39] Lüthje, C. (2002) 'Characteristics of Innovating Users in a Consumer Goods Field', *Technovation*, forthcoming.

[40] MacCarthy, B.M., Bramham, J. and Brabazon, P.G. (2002) 'Mass Customization Operations Modes', in S. Beckman and K.K. Sinha (Eds.) *Proceedings of the POMS 2002 Conference*, San Francisco.

[41] Maes, P. (1994) 'Agents that Reduce Work and Information Overload', *Communications of the ACM*, Vol. 37, No. 7, pp. 31-40, 146.

[42] Meuter, M. L. et al. (2000) 'Self-service technologies: Understanding customer satisfaction with technology-based service encounters', *Journal of Marketing*, Vol. 64, No. 3, pp. 50-64.

[43] Milgrom, P. and Roberts, J. (1990) 'The Economics of Modern Manufacturing: Technology, Strategy, and Organization', *The American Economic Review*, Vol. 80, pp. 511-528.

[44] Miller, G. A. (1956) 'The Magic Number Seven, Plus or Minus Two: Some Limits on our Capacity for Processing Information', *The Psychological Review*, Vol. 63, pp. 81-97.

[45] Mishler, E. (1986) *Research Interviewing: context and narrative*, Cambridge: Harvard University Press.

[46] Neumann, J. (1955) 'Can We Survive Technology?', *Fortune*, Vol. 91, No. 6, p. 106.

[47] Ng, K.Y.M. (2000) *Customizable 3D Virtual Objects: A Breakthrough in Electronic Catalogs in Internet Business*, MPhil thesis, Dept. of Industrial Engineering and Engineering Management, The Hong Kong University of Science and Technology, Hong Kong.

[48] Nicholas, S., Haldane, C. and Wilson, J.R. (2000) 'Measurement of presence and its consequences in virtual environment', *International Journal of Human-Computer Studies*, Vol. 52, pp. 471-491.

[49] Nielsen, J. (1995) *Multimedia and Hypertext: The Internet and Beyond*, Boston: AP Professional.

[50] Nielsen, J. (2001) 'Top Ten Mistakes in Web Design', in Karwowski, W. (Ed.) *International Encyclopedia of Ergonomics and Human Factors*, New York: Taylor & Francis, Ltd., pp. 738-740.

[51] Normann, R. and Raminez, R. (1994) 'From value chain to value constellation', *Harvard Business Review*, Vol. 71, No. 4, pp. 65-77.

[52] Novak, T.P., Hoffmann, D.L. and Yung, Y.-F. (2000) 'Measuring the Customer Experience in Online Environments: A Structural Modeling Approach', *Marketing Science*, Vol. 19, pp. 22-42.

[53] Oon, Y. B. and Khalid, H. M. (2001) 'Usability of Design by Customer Web Sites for Mass Customization', M.M. Tseng and F.T. Piller (Eds.) *Proceedings of the World Congress on Mass Customization and Personalization MCPC 2001*, Hong Kong.

[54] Park, C.W., Mothersbaugh, D.L. and Feick, L. (1994) 'Consumer knowledge assessment', *Journal of Consumer Research*, Vol. 21, pp. 71 – 82.

[55] Patterson, P., Johnson, L. and Spreng, R. (1997) 'Modeling the determinants of customer Satisfaction for Business-to-Business Professional Services', *Journal of the Academy of Marketing Science*, Vol. 25, pp. 4-17.

[56] Piller, F. (2001) *Mass Customization*, 2nd edition, Wiesbaden: Gabler.

[57] Piller, F. and Schoder, D. (1999) 'Mass Customization and Electronic Commerce', *Zeitschrift fuer Betriebswirtschaft*, Vol. 69, pp. 1111-1136.

[58] Piller, F., Schaller, C. and Reichwald, R. (2002) 'Building customer loyalty with collaboration nets', in Q. Mills et al (Eds.), *Collaborative Customer Relationship Management*, New York: Wiley 2002, chapter 4 *(forthcoming)*.

[59] Pine, B.J. (1993) *Mass Customization*, Boston: Harvard Business School Press.

[60] Pine, B.J., Peppers, D. and Rogers, M. (1995) 'Do you want to keep your customers forever?', *Harvard Business Review*, Vol. 73, No. 2, pp. 103-114.

[61] Polanyi, M. (1958/1974) *Personal Knowledge: Towards a Post- Critical Philosophy*. Chicago: University of Chicago Press.

[62] Polley, D. and Van de Ven, A.H. (1995) 'Learning by Discovery during Innovation Development', *International Journal of Technology Management,* Vol. 11, pp. 871-883.

[63] Ramirez, R. (1999) 'Value Co-Production: Intellectual Origins and Implications for Practice and Research', *Strategic Management Journal*, Vol. 20, pp. 49-65.

[64] Riemer, K. and Totz, C. (2001) 'The Many Faces of Personalization - an Integrative Economic Overview', in M.M. Tseng and F.T. Piller (Eds.) *Proceedings of the World Congress on Mass Customization and Personalization MCPC 2001*, Hong Kong.

[65] Shah, S. (2000) *Sources and Patterns of Innovation in a Consumer Products Field: Innovations in Sporting Equipment,* MIT Sloan Working Paper #4105, Cambridge, MA.

[66] Stabell, C. B. and O. D. Fjeldstad (1998) 'Configuring value for competitive advantage: on chains, shops, and networks', *Strategic Management Journal*, Vol. 19, pp. 413–37.

[67] Strauss, R. and Schoder, D. (2000) *e-Reality 2000*, Frankfurt: Consulting Partner Group.

[68] Teresko, J. (1994) 'Mass Customization or Mass Confusion', *Industry Week*, Vol. 243, No. 12 pp. 45-48.

[69] Thomke, S. and von Hippel, E. (2002) 'Customers as Innovators: A New Way to Create Value', *Harvard Business Review*, Vol. 80, No. 2 (April).

[70] Thomke, S., von Hippel, E. and Franke, R. (1998) 'Modes of Experimentation: An Innovation Process - and Competitive - Variable', *Research Policy*, Vol. 27, pp. 315-332.

[71] Tian, K.T., Bearden, W. O. and Hunter, G. L. (2001) 'Consumers' Need for Uniqueness: Scale Development and Validation', *Journal of Consumer Research*, Vol. 28, June, pp. 50-66.

[72] Toffler, A. (1970) *Future Shock*, New York: Bantam Books.

[73] Totz, C. and Riemer, K. (2001) 'Usability of Design by Customer Web Sites for Mass Customization', in M.M. Tseng and F.T. Piller (Eds.) *Proceedings of the World Congress on Mass Customization and Personalization MCPC 2001*, Hong Kong.

[74] Tseng, M.M. and Du, X. (1998) 'Design by Customers of Mass Customization Products', *CIRP Annals*, Vol. 47, pp. 103-106.

[75] Tseng, M.M. and Jiao, J. (2001) 'Mass Customization', in G. Salvendy (Ed.) *Handbook of Industrial Engineering*, 3rd edition, New York: Wiley, pp. 684-709.

[76] Vandermerwe, S. (2000) 'How Increasing Value to Customers Improves Business Results', *Sloan Management Review*, Vol. 42 , pp. 27-37.

[77] Vickery, S., Droge, C. and Germain, R. (1999) 'The Relationship Between Product Customization and Organizational Structure', *Journal of Operations Management*, Vol. 17, pp. 377-391.

[78] Von Hippel, E. (1978) 'Successful Industrial Products from Customer Ideas', *Journal of Marketing*, Vol. 42, pp. 39-52.

[79] Von Hippel, E. (1988) *The Sources of Innovation,* New York: Oxford University Press.

[80] Von Hippel, E. (1998) 'Economics of Product Development by Users: The Impact of "Sticky" Local Information', *Management Science*, Vol. 44, No. 5 (May) p. 629-644.

[81] Von Hippel, E. (2001) 'Perspective: User Toolkits for Innovation', *The Journal of Product Innovation Management* Vol. 18, pp. 247-257.

[82] Von Hippel, E. and Tyre, M. (1995) 'How Learning is Done: Problem Identification in Novel Process Equipment', *Research Policy,* Vol. 24, pp. 1-12.

[83] Vora, P. (1998) 'Human Factors Methodology for Designing Web sites', in C. Forsythe, E. Grose and J. Ratner (Eds.) *Human Factors and Web Development*, New Jersey: Lawrence Erlbaum Associates.

[84] Westland, J.C. and Au, G. (1998) 'A Comparison of Shopping Experiences Across Three Competing Digital Retailing Interfaces', *International Journal of Electronic Commerce*, Vol. 2, pp. 57-69.

[85] Weston, R. (1997) 'Web Automation', *PC Week*, No. 32, p. 76.

[86] Wikström, S. (1996) 'Value Creation by Company-Consumer Interaction', *Journal of Marketing Management*, Vol. 12, pp. 359-374.

[87] Workman, J., Homburg, C. and Gruner, K. (1998) 'Marketing Organization: an Integrative Framework of Dimensions and Determinants', *Journal of Marketing*, Vol. 62, pp. 21-41.

[88] Zipkin, P. (2001) 'The Limits of Mass Customization', *Sloan Management Review*, Vol. 42, pp. 81-87.

Appendix

Table 1: Cases Covered in the Exploratory Phase of the Project

Company	Products	Markets
Cove (www.cove.com)	men's (formal) wear	Germany
Creo (www.creo-shoes.com)	fashion shoes	world wide (but mainly Germany and USA)
Customatix (www.customatix.com)	fashion shoes	USA
Dell Computers (www.dell.com)	PCs	world wide
Idtown (www.idtown.com)	watches	world wide (major markets are Japan, Germany, UK, USA)
Interactive Custom Clothes Company Designs (www.ic3d.com)	jeans	USA
Lands' End (www.landsend.com)	khakis (trousers)	USA
Lego (www.lego.com)	comics, special toy kits (Mosaic product line)	world wired (major markets are USA, Canada and Germany)
miAdidas (www.miadidas.com)	sport shoes (soccer, running, basketball)	Germany, UK, Netherlands, Italy, Japan, Korea, USA
NikeID (www.nike.com)	sport shoes (design)	USA, Germany, Japan
Reflect.com (www.reflect.com)	cosmetics and body care	USA
Selve AG (www.selve.net)	women's footwear	Germany
Sovital (www.sovital.de)	vitamin products	Germany
Timbuk2 (www.timbuk2.com)	bags and luggage	USA, Canada (minor markets are Europe)
Westbury by C&A (www.CundA.de)	men's (formal) wear	Germany

Table 2 Empirical Research on Mass Customization and Related Fields

	Research question	Type	Field	Method	Findings
Ahlström/Westbrook (1999)	What are the implications of mass customization for operations management?	Survey; subject of research: machinery	various branches of industry, mostly b-to-b	descriptive statistics, correlation analysis	Mass customization is seen as an interesting form of differentiation with specific patterns of design of operations. Study lacks clear differentiation between mass customization and traditional craft customization.
Bauer/Grether/Leach (1999)	Does customization / personalization influence customer relationship intensity?	Survey, (n=94); subject of research: managers	US online brokers for financial services, real estate, travel; online book and music sellers	Covariance Structure Model (LISREL)	(1) Level of interaction is positively related with all three measures of relationship intensity (user satisfaction, commitment, trust; as perceived by the management of the firms) (2) commitment is showing the strongest significance coefficient; user satisfaction is only (weakly) significantly related
Dellaerta et al. (2001)	How do consumers handle choice of modularized products?	Survey (n=728), simulation; subject of research: customers	Tourism: customization of travel packages	Conjoint choice experiment, micro-simulations	Under modularization, producers of products with structural utility benefits are better off offering their competitively weaker modules separately while bundling their competitively stronger modules with weaker modules
Duray et al. (2000)	How can mass customizers be classified?	Survey (n=126); subject of research: managers	Various industries in the USA	Exploratory Factor Analysis, ANOVA	Development of a configurationally model for classifying mass customizers from the perspective of operations Two variables are key in classifying mass customizers: (1) the point in the production cycle where the customer is involved in specifying the product [design/fabrication – assembly/use] (2) the type of modularity used in the product [design/fabrication – assembly/use]
Feitzinger/Lee (1999)	How does a large electronics manufacturer	Case study	Electronics industry (Hewlett-Packard)	Interviews, qualitative assessment	Postponement is identified and described as key enabler of mass customization

	Research question	Type	Field	Method	Findings
	deploy mass customization?				
Franke/Mertens (2001)	How do users perceive, handle and evaluate personalization within complex information systems?	Case studies and field experiments	Evaluation of pilot platforms of the use of customization in management information systems (MIS), training and advising systems, tourism planning system	Interviews, qualitative assessment	(1) Privacy and acceptance to use this systems is their largest hurdle for implementation (2) Perception of usefulness and value-added is major success factor of the use of these systems
Franke/von Hippel (2002)	Do "toolkits for user innovation" benefit users?	Survey (n=138); subject of research: customers	Open Source Software	Cluster analysis, heterogeneity index, willingness to pay (WTP) scale	(1) Needs among users of web server software are highly heterogeneous (2) Dissatisfaction with standard offerings is high (3) Users who used the toolkit and created their own product are significantly more satisfied than users who only used the standard products
Gruner/Homburg (2000)	What is the impact on new products' success of (1) the degree of consumer interaction in different stages of new product development and (2) the characteristics of the involved customers?	Survey (n=310); subject of research: managers	(German) machinery industry	Confirmatory factor analysis for measure validation, cluster and discriminant analysis	(1) Degree of customer interaction in early and late stages of new product development process increases new product success (but not in middle stages of development of technical solution) (2) customers with lead user characteristics, financially attractive customers and close customers are most attractive interaction partners.
Huffman/Kahn (1998)	Does complexity inherent with a wide number of options lead to customers' dissatisfaction "mass confusion"?	Survey / experiments (n=79 and n=65); subject of research: customers	(a) Customization of stay in hotels (b) Customization of sofa	Regression analysis	(1) Attribute based presentation is preferred to alternative based presentation of customization items; (2) Process satisfaction is related to degree of input in an inverted u-shaped fashion (3) Retailers should explicitly inquire customer's preferences and help consumers to learn their own preferences
Khalid/Helander (2001)	How does the cultural	Survey	Watch industry	Correlation analysis	(1) Users follow top-down approach represented

	Research question	Type	Field	Method	Findings
	background of a user influence its use and satisfaction of a configuration tool on the Internet?	(n=137); subject of research: customers	(Idtown.com), comparison of two cultural backgrounds of users within one region (Hong Kong versus Malaysia)		by the product structure (2) Malaysian users show larger enthusiasm towards the idea of customization than Hong Kong subjects (2) Malaysian users evaluate the function "show and manage time" as main benefit of a watch much higher than Hong Kong users, who evaluate aesthetics and style higher
Kotha (1996)	What are the management processes and organizational structures of an early mass customization pioneering company ?	Case study with longitudinal data	Bicycle industry (National Industrial Bicycle Company of Japan)	Interviews, qualitative assessment	(1) The interaction of mass customization and mass production systems can be an effective source of knowledge creation and of organizational learning; (2) Identification of external and internal success factors of mass customization
Liechty/Ramaswamy/Cohen (2001)	How can customizable features on a choice board be evaluated?	Survey and experiment (n=360); subject of research: customers	Web-based information services (Internet Yellow pages)	Bayesian approach for menu-based conjoint analysis, fractional factorial research design; correlation analysis	Development and concept proof of experimental choice menus for assessing customers' preferences and price sensitivity for features offered on a choice board
MacCarthy/Bramham/Brabazon (2002)	How can different operations modes of mass customization be classified?	5 case studies	Consumer goods, consumer electronics, electronic equipment, commercial vehicles	Interviews, qualitative assessment: classification of the case studies against the schemes identified in the literature	(1) Mass customizers differ from mass producers and (craft) customizers in regard to the environments in which the products are offered, the customization strategy, and operational practices and resources used. (2) Basic enablers of mass customization (in regard to customer integration) are the exposure to market fluctuations required and the strategic involvement of customers to meet existing modular product structure.
Meuter et al. (2000)	What are sources of satisfaction and dissatisfaction with self-service technologies from the users' perspective?	Survey (n = 823); subject of research: customers	Various branches of industries using self service technologies (mostly ATM and online shopping sites)	Critical incident study, eliciting descriptions of memorable incidents by users, in addition	(1) Degree of user expectation when using self service (configuration) is higher compared to interpersonal interaction; (2) degree of customization offered of by self service technologies is positively correlated with

	Research question	Type	Field	Method	Findings
				quantitative methods like regression and correlation analysis between clusters	user satisfaction; (3) largest factor of satisfaction was the degree of perceived advantage of using technologies; second largest error-free functionality ("just did its job")
Ng (2000) (similar findings report Johnson 1998, Nicholas et al 2000, Westland / Au 1998)	Does 3D visualization in Internet shopping lead to higher user satisfaction and higher propensity of purchase?	Survey (n=80); subject of research: customers	Consumer electronics (evaluation of three different electronic products in different presentation forms)	Experiment, correlation studies	(1) 3D visualization increases user satisfaction (compared to 2D images) (2) 3D visualization increases propensity of purchase (compared to 2D images), however higher experience of sickness when site is not performing technically
Oon /Khalid (2001)	How does web site design and usability of online configurators influence user satisfaction and site efficiency in supporting design activity ?	Survey (n=48); subject of research: customers	Three mass customization web sites (clothes: squash-blosson.com, watches: Idtown.com; bycicles: voodoo-cycles.com)	One-way repeated measures ANOVA, factor analysis, principal component method	(1) In comparison to other sites, Idtown was found to be significantly flexible to navigate (during configuration); however, users complained about too little information. (2) Highest willingness to purchase product at Idtown side. (3) Hierarchical structure of product components allows users to complete the design (configuration) task better
Piller (2001)	What different process structures for mass customization exist, and what are best practices?	Case study research (n=120)	Various branches of industry (60% b-to-c; 40% b-to-b); (40% German, 40% US, 20% ROW companies)	Interviews, qualitative assessment	Anecdotal evidence of success factors of mass customization: (1) Clear definition of "solution space" (2) Translation of modular product/service structures with configuration tool (3) Smooth interfaces between product configuration and order fulfillment (4) No iterations between sales and fulfillment once order was placed (5) Closed "knowledge loop" (6) Top management support, clear governance structures concerning who owns the system
Piller/Schoder (1999)	What is the state of art of connecting mass customization and customer relationship management?	Survey (n=914); subject of research:	German companies; various branches of industry, most companies (79%) are	Descriptive statistics, correlation analysis	(1) Companies are employing mass customization to get stronger position of differentiation (2) Lack of sufficient information management is main hurdle

	Research question	Type	Field	Method	Findings
		managers	operating in the b-to-b market		(3) Use of customer data for building customer relationships is rather weak
Strauss/Schoder (2000)	What are the status, development, success factors and management implications of mass customization?	Survey (interviews) (n=1308); subject of research: managers	German, Austrian and Swiss companies of various industries	Descriptive statistic	(1) The strategy of mass customization is seen by a third of the companies of increasing importance in future (2) financial services and utilities offer fewer individual products (3) mass customization is connected with more customer satisfaction (from the perspective of managers)
Tian / Bearden / Hunter (2001)	How can consumers' need for uniqueness be evaluated (scale development)?	Two surveys (n=273; n=621); subject of research: customers	personal experiences of users (no specific fields)	Validation studies with three-factor oblique model, measurement of factor loadings; validation studies	Development of a scale to evaluate consumers' need for uniqueness (self perception of uniqueness). Scale is defined by creative choice counter conformity, unpopular choice counter conformity, avoidance of similarity.
Vickery/Droge/Germain (1999)	What is the relationship between product customization and organizational structure?	Survey (n=217); subject of research: managers	US manufacturers, various branches of industry	Covariance Structure Model (LISREL)	Customization associates with more formal control, fewer layers, narrower spans of control.
von Hippel (1998)	What are the economics of product development by users?	Case studies	Application-specific integrated circuits (ASICs); computer telephony integration systems (CTI)	Qualitative assessment	Anecdotal evidence that user-driven product development pays off (impact of “sticky” local information).
von Hippel (2001)	What are the benefits of toolkits for user innovation?	Case study	Food Industry (Nestlé)	Qualitative assessment	By the use of a toolkit the normal time of 26 weeks for development of a novel food product for an industrial customer was reduced to 3 weeks on average
Thomke/Von Hippel (2002)	What are business models and strategy implications of toolkits for user innovation?	Case studies	Flavor industry (BBA), plastic industry (GE Plastics)	Qualitative assessment	Toolkits for user innovation demand organizational changes, allow improved design processes, make it to shift the design risks to the customers, increase customer satisfaction, and help

Research question	Type	Field	Method	Findings
				to attract new customers