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CO-DESIGN IN ZAMBIA - AN EXAMINATION OF DESIGN OUTCOMES

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Abstract

After decades of limited success "designing for the developing world", it is clear that Base of the Pyramid (BoP) markets are complex and face unique challenges, such as large geographical distances between designers and users as well as poor understanding of user/customer needs. Participatory design has emerged as a strategy to improve user/customer understanding in BoP markets in hopes that it may lead to improved design outcomes. This study aims to better understand the relationship between co-design and related participatory design approaches with design outcomes. An experiment was conducted in rural Zambia in partnership with an agricultural enterprise and also at a university in the USA, and the resulting design outcomes compared with the level of end-user/customer participation. Concepts rated with the highest likelihood of adoption were generated by teams composed entirely of end-users/customers, however these were also among the least creative concepts. Teams that employed user-centered design produced concepts with mixed results, and teams that followed a co-design approach produced concepts with the greatest balance of creativity, feasibility, and meeting the need.

Keywords: Design process, User centred design, Participatory design, Social responsibility, Co-design

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1 INTRODUCTION

A central role of engineering design is to meet the needs of humanity. Recent engineering design literature and practice have shown significant interest in alleviating poverty in less-industrialized economies (Schafer, Parks and Rai 2011, Austin-Breneman and Yang 2013, Mattson and Winter 2016). After decades of limited success "designing for the developing world" (Donaldson 2008, Mattson and Wood 2014), it has become clear that so-called Base of the Pyramid (BoP) markets are complex and face unique challenges, such as large geographical distances between designers and potential users and poor understanding of user/customer needs and desires (Wood and Mattson 2016).

Participatory design approaches have emerged in response to the need for improved user/customer understanding, particularly in BoP markets. These approaches, including user-centered design and co-design are seen as ways to increasingly engage stakeholders and better incorporate their needs, desires, constraints, assets and ideas into the design process. A growing body of practitioners employ co-design in hopes that this may lead to improved design outcomes as well as build agency within stakeholders involved in the design process. This study aims to better understand the effects of co-design on design outcomes. We describe a design experiment conducted in 2016 in rural Zambia and at a university in the USA in partnership with an agricultural social venture based in Chipata, Zambia.

We aim to address the following research questions:

In a BoP context, how does the level of end-user/customer participation in generative design activities (user-centered design vs. co-design vs. user-generated design) affect design outcomes?

a. How does the level of participation affect how well designs meet user/customer needs?
b. How does the level of participation affect the creativity and feasibility of designs?
c. How does the level of participation affect the likelihood of adoption?

2 BACKGROUND

2.1 Design for BoP Markets

Design for BoP markets – also known as design for development, design for the developing world, and design in less-industrialized economies – can be found in literature ranging from business and entrepreneurship, engineering design, international development, sociology to engineering education.

Within the business community, Prahalad famously framed BoP markets as areas of emerging, high-growth market potential (2009). As of 2008, BoP markets represented an estimated US$5 trillion of demand (Subrahmanyan and Tomas Gomez-Arias). As multinational corporations began expanding into BoP markets, social entrepreneurship and the impact investment industry also emerged (Martin and Osberg 2007, Brest and Born 2013). Despite two economic downturns, impact investing has grown significantly in the past two decades, with a four-quarter rolling average of over US$5 billion invested by the 51 firms included in the Impact Investing Benchmark (Cambridge Associates and GIIN, 2015). While this has attracted many new product development efforts targeting BoP markets, start-ups and multi-national corporations have experienced limited profitability through serving BoP customers. In response, researchers such as Hart and Simanis (2008) and Duke and Simanis (2014) have developed tools for assisting BoP businesses in co-creating value with their target customers while not losing sight of scalability and profitable unit economics, and communities of practice have formed to develop recommendations for fostering effective co-design in BoP markets (MIT PIA, 2015).

Engineers and product designers have their own history of product development in BoP markets ranging from appropriate technologies to user-centered design, participatory design, empathic design, and reverse innovation (Mattson and Wood, 2014). In recent years, engineering students, educators, and professionals have become increasingly interested in design for BoP markets (Mattson and Winter, 2016; Litchfield and Javernick-Will, 2015). While there are examples of product design efforts – such as iDE, Greenlight Planet, M-Kopa, D-Rev, Jain Irrigation, and Nokia – that have had significant impact in BoP markets (Austin-Breneman and Yang, 2013), these appear to be relatively few and far between.

Through study of one sample of 41 engineering design projects from their own work and Engineers Without Borders, Wood and Mattson (2016) found that the following two pitfalls were responsible for over half of reported failures: (1) lacking the contextual knowledge needed for significant impact (29%), and (2) assuming the needs of customers being served (24%). Taken together, the above research suggests that end-user/customer involvement is an important factor in the success or failure of designs in BoP markets.

2.2 Participatory Design

The practice of participatory design has emerged in response to the need for improved understanding of local context as well as user/customer wants and needs (Binder et al. , 2008). Approaches to participatory design range from user-centered design, co-design, to user-generated design. These may be viewed as a spectrum of end-user/customer participation, as shown in Figure 1.

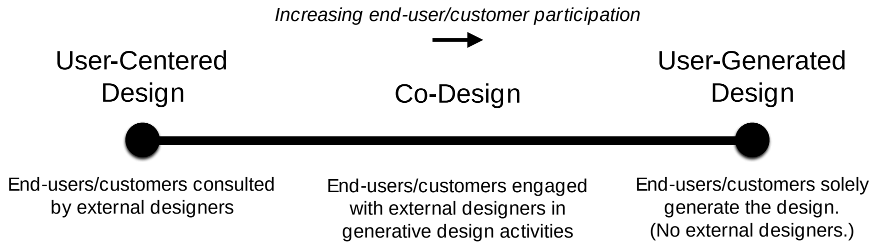

Figure 1. A spectrum of participatory design

User-centered design (Norman, 1988) is a practice through which stakeholders (e.g. end-users/customers) are consulted throughout a design process by a team of non-stakeholder designers. User-centered design typically views stakeholders as informers from whom insights may be discovered. Co-design differs from user-centered design in that there is a higher degree of stakeholder participation. According to Sanders and Stappers (2008), co-design refers to an act of collective creativity between designers and people not trained in design working together in a design process. In co-design, stakeholders are viewed as design partners and active co-creators. We define co-design as a process in which key stakeholders and external designers together perform generative design activities such as ideation and prototyping. At the other end of the spectrum is user-generated design, an approach in which stakeholders are sole generators of the design. This approach reframes the end-user/customer, shifting them from a mere user or recipient of a product to an active creator (Smith, 2010). A different but related idea is the development of products by lead users as described by von Hippel (2005).

Co-design has roots in Community-Based Participatory Research (CBPR), a practice aimed at increasing community participation and ownership in the development of initiatives or interventions. CBPR has been applied to a wide range of fields (Michalak et al., 2016), and, at the same time has received criticism for sometimes being more rhetoric than substance and subject to manipulation by external bodies pursuing their own agendas under a pretence of community consent (Cooke and Kothari, 2001). Co-design is vulnerable to similar malpractice and criticism.

Co-design has been applied to the development of healthcare services (Aitken and Shackleton, 2014), digital health technologies (Sharma et al., 2016), sanitation systems (iDE), farming systems (Cerf and Al., 2009), and the co-creation of value in business (Prahalad and Ramaswamy, 2004, Hart and Simanis, 2008; Minka-Dev). More recently, Sanders and Stappers have put forth a toolbox of methods for effective co-design (2013). Overall, the literature suggests a need for improved understanding of local context and user/customer wants and needs, especially in design for BoP markets. This may be improved by increasing the level of end-user/customer participation in the design process through, for example, co-design (Kleinsmann and Valkenburg, 2008; Steen et al., 2011; Kimita et al., 2016). However, the effects of stakeholder participation on design outcomes remains an open question. This study assesses design outcomes across the spectrum of participatory design in a BoP setting: rural Zambia.

3 PARTICIPATORY DESIGN EXPERIMENT IN ZAMBIA

This study was conducted in partnership with an agricultural social enterprise based in Zambia whose mission is to generate lasting income with smallholder farmers. The Enterprise does so through a network of private extension agents who deliver loans of seed and other inputs while training and supporting farmers to use agricultural practices that produce high yield and improve the long-term viability of their soil. At harvest, the Enterprise buys certifiable seed back from their farmers which allows farmers to earn dramatically increased incomes. However, farmers' yields are limited by access to high capital cost agricultural implements such as oxen, ox carts, ploughs, and rippers. In response, the Enterprise desired to work with their farmers to co-design possible solutions to this challenge. In collaboration with this enterprise, the authors developed and ran three separate design workshops: one in rural Zambia in January 2016; one at a university in the USA in June 2016; and another in the same area of Zambia in August 2016. Zambia and this enterprise were chosen for this study because of the Enterprise's interest and prior experience with co-design; their compelling mission in a BoP setting; and their desire to work with their stakeholders to co-design solutions to a pressing challenge.

3.1 Study Design

Over the course of three workshops, eleven design teams each consisting of 4-5 people were provided with the same design challenge: how to improve access to high capital cost agricultural implements (e.g. ploughs, rippers, oxen, ox carts) for farmers in a certain village in Zambia. Each team was guided through a common design process over the course of a similar period of time (~2 hours). The variable in this experiment is team composition – in particular, the level of participation of potential end-users/customers in the teams was varied. For example, Team 3 was composed of all farmers from the Village, while Team 4 was composed of one Village farmer and four experienced designers from Zambia and USA.

The design process proceeded roughly as follows: introduction to and confirmation of the design challenge; teams formed and an optional design warm-up activity; introduction to brainstorming and a brainstorming warm-up activity; idea generation; concept selection using a Pugh chart; and final concept presentation. Each participant was provided with a pen and design notebook, and each team was given a stack of blank white printer paper, markers, and tape. Each teams' final concept presentation was captured using photographs and video. Then all final concepts were represented by a sketch artist with English and Nyanja captions, as exemplified in Figure 4. These 11 bi-lingual sketches were presented and rated by individual judges, and these scores were used to assess design outcomes.

An introductory design activity was run with teams that included farmers from the Village in order to help establish an environment in which farmers were comfortable participating actively, and to allow teams to rapidly practice a full design cycle together. To build Village farmer comfort and alleviate potential power imbalances that may exist between, for example, a rural Zambian farmer and a highly educated urban Zambian engineer, this introductory activity was chosen such that a rural Zambian farmer would likely contribute as much or more to the activity than external designers.

While the core design activities – idea generation and concept selection – took a similar period of time, each of the three workshops varied in the overall time and amount of training provided. For example, the January 2016 workshop occurred over five days, about 20 hours, and included significant training and practice in design process, whereas the June 2016 workshop lasted for just two hours and included only ideation, concept selection, and presentation. Overall, for logistical reasons, nine teams developed their concepts at workshops in the Village and two (Teams 9 and 10) at the workshop in USA.

3.2 Subjects

3.2.1 Design Team Participants

The workshop participants included smallholder farmers from the Village, visitors from other parts of Zambia with prior design experience, and students from design courses at a university in USA. Measures were taken to select external designers with prior training and skill in working in diverse teams. The workshop facilitator observed for team dynamics that might inhibit a team's performance and administered an exit survey that asked for participants' opinions on their project and participation within their team. Additionally, at the start of the workshops, participants completed an entrance survey with questions to assess demographics and prior experience in design and farming.

3.2.2 Measuring Attributes of Team Composition

The entrance survey results and experience rating rubric in Table 1 were used to rate participants' levels of experience in design and farming. Individual experience ratings are summed to find each team's total experience in both design and farming, and then normalized. Table 2 displays team demographics, design and farming experience ratings, and the number of farmers from the Village (potential end-users/customers) per team. Figure 2 shows that of the eleven teams, five employed a user-generated design approach; three took a co-design approach; and three followed a user-centered design approach.

Table 1. Rating Rubrics for Farming and Design Experience of Participants

Farming	Design
0 = None	0 = None
1 = Exposure	1 = Exposure
2 = Maintain a garden	2 = Building trade
3 = Part-time farming	3 = One-week design training
4 = Full-time farm, several years	4 = One-month design training
5 = Full-time farm, 10-20 years	5 = Design-related undergraduate
6 = Full-time farm, 20-30 years	6 = Design professional

Table 2. Team Demographics and Experience Levels

Team	Number of Males, Females	Average Age	Stdev. Age	Nationalities	Number of Farmers from the Village	Normalized Total Farming Experience	Normalized Total Design Experience
1	2, 3	46	9.0	Zambia (5)	5	1.00	0.00
2	2, 3	40	7.7	Zambia (5)	5	0.88	0.00
3	3, 2	37	8.4	Zambia (5)	5	0.88	0.00
4	2, 3	31	14.0	Zambia (5)	5	0.75	0.00
5	3, 2	33	13.7	Zambia (5)	5	0.75	0.00
6	2, 3	37	9.4	Zambia (4) USA (1)	4	0.75	0.17
7	2, 3	41	15.6	Zambia (4) USA (1)	2	0.78	0.57
8	3, 2	41	16.6	Zambia (4) USA (1)	1	0.78	0.78
9	2, 2	20	1.3	Ethiopia (1) Iceland (1) USA (2)	0	0.16	0.70
10	1, 3	21	2.2	Chile (1) USA (3)	0	0.19	0.78
11	3, 2	28	5.0	Zambia (3) USA (2)	0	0.31	1.00

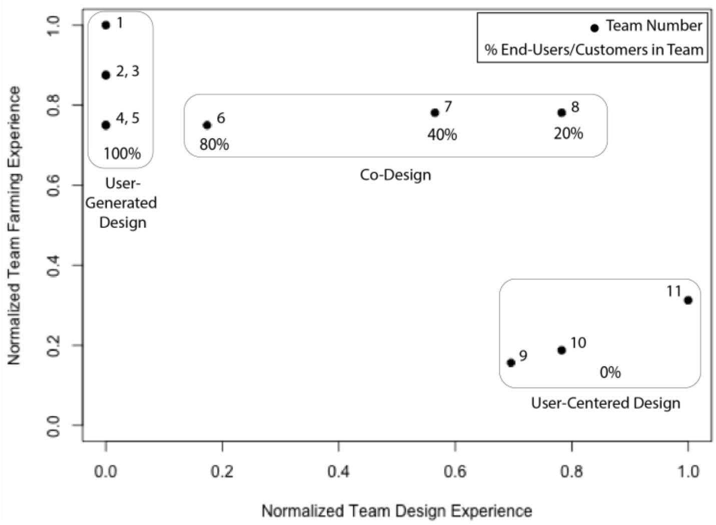

Figure 2. Team Composition in terms of Design Experience, Farming Experience, and Percentage of End-Users/Customers

3.2.3 Judges and Measuring Design Outcomes

Six agricultural experts with experience in rural Zambia – four highly experienced farmers from the Village and two agricultural extension officers working in the Village – were recruited to rate each of the final concepts in terms of: (1) Need – meets a real need in the Village, (2) Feasibility – is likely to work in the Village, (3) Creativity/Newness – is a new idea to the Village, (4) Likelihood of Adoption – is likely to be adopted by farmers in the Village. These measures are adapted from previous literature (Shah et al., 2003; Kudrowitz and Wallace, 2013).

4 RESULTS

Figures 3 and 4 show three example final design concepts and their representations as shown to judges. Results from surveying judges are discussed in the following sections.

Figure 3. Example sketches of concepts that received high likelihood of adoption ratings

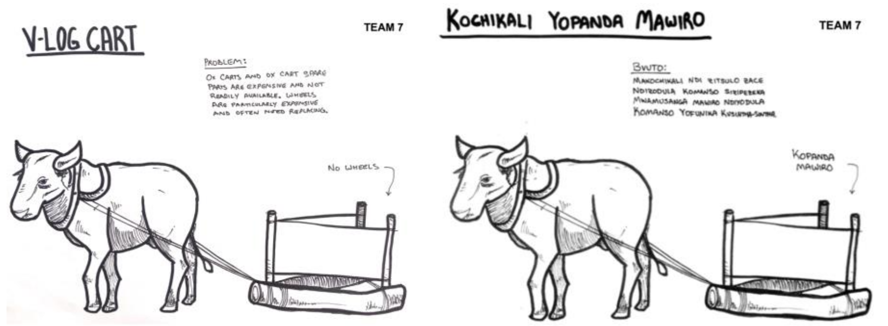

Figure 4. Sketches of a concept with low likelihood of adoption rating, in English and Nyanja

4.1 Design Outcomes

The average likelihood of adoption for all concepts as assessed by judges is shown in Figure 5. Error bars represent +/- one standard error of the mean. Notably, the two concepts with the highest likelihood of adoption ratings (Concepts 1 and 2) were generated by user-generated design teams (composed of entirely potential end-users/customers), and these two concepts were selected and implemented by the Enterprise in Zambia. While it appears that concepts from the user-generated design teams generally exhibit higher likelihood of adoption ratings than concepts from co-design or user-centered design teams, these differences are largely not statistically significant.

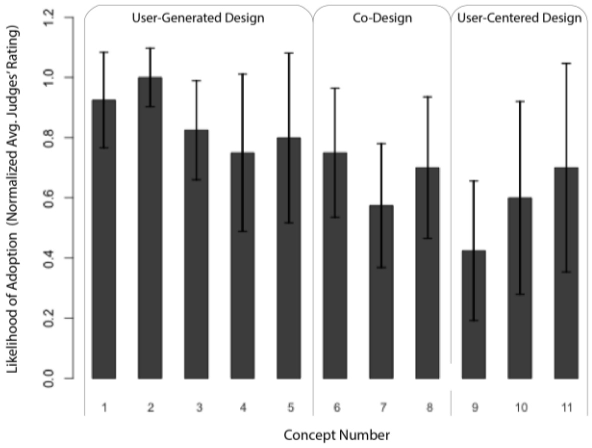

Figure 5. Concept Likelihood of Adoption as Rated by Judges

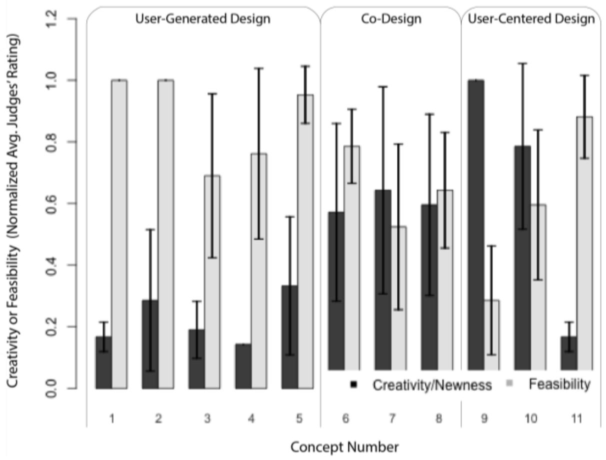

Figure 6. Concept Feasibility and Creativity/Newness as Rated by Judges

Average rated concept feasibility and creativity/newness is shown in Figure 6. Interestingly, all concepts developed through user-generated design exhibit significantly higher feasibility than creativity while all concepts generated through co-design offer a relative balance of feasibility and creativity. User-centered design concepts offer a mixed bag – one concept with significantly higher creativity than feasibility; one concept with significantly higher feasibility than creativity; and one concept with a relative balance. This may be explained by the difference in workshop location – Concepts 9 and 10 were developed in USA and Concept 11 was developed in the Village in Zambia. Additionally, the differences may be explained by the diversity of nationalities and number of Zambians participating in the three user-centered design teams (see Table 2). Team 11 included three Zambian designers with farming experience who were not from the Village, however the perspectives of these Zambians appear to have affected the team in ways similar to the co-design or even user-generated design teams. Teams 9 and 10 were composed of only non-Zambians, and members of Team 9 were from especially diverse nationalities which may in part explain why this team developed a highly creative concept. The observation that a culturally diverse team is associated with producing creative or innovative work is in agreement with previous studies (Maddux *et al.*, 2009). Also, the finding of a generally negative correlation between concepts judged to be highly feasible and those judged to be highly creative – as seen in the cases of user-generated and user-centered design concepts – is supported by a previous study (Häggman et al., 2015), and not supported by another that found a generally negligible correlation between "novel" and "useful" concepts (Kudrowitz and Wallace, 2013).

4.2 Level of Participation and Design Outcomes

The research questions under examination ask how the level of end-user/customer participation in generative design activities (user-centered design vs. co-design vs. user-generated design) affects design outcomes such as creativity, feasibility, meeting the need, and likelihood of adoption. Table 3 displays Spearman correlations between design outcomes and team composition as measured by the percentage of end-users/customers (Village farmers), team farming experience, and team design experience.

Table 3. Spearman correlations between design outcomes and team composition

	1	2	3	4
1. Addresses Real Need (Judges' Ratings)				
2. Feasibility (Judges' Ratings)	0.94***			
3. Creativity/Newness (Judges' Ratings)	-0.71*	-0.69*		
4. Likelihood of Adoption (Judges' Ratings)	0.86***	0.84**	-0.68*	
5. Percentage End-Users/Customers in Team	0.63*	0.67*	-0.61*	0.86***
6. Team Farming Experience	0.49	0.33	-0.43	0.72*
7. Team Design Experience	-0.52	-0.62*	0.49	-0.78**

N = 11. *** p <.001, ** p <.01, * p <.05

Observe that addressing a real need, feasibility, and likelihood of adoption ratings have a significant positive correlation with one another and the percentage of end-users/customers in the team – and conversely, a significant negative correlation with rated creativity/newness. Thus, in this scenario, increasing the level of end-user/customer participation in a team's design process is associated with decreasing concept creativity and increasing concept feasibility, likelihood of adoption, and how well concepts meet user/customer needs.

4.3 Limitations

The results of this study may be limited to the context of relatively approachable challenges in settings similar to rural Zambia. For example, it is expected that high end-user/customer participation (e.g. user-generated design) in developing concepts for challenges of greater technical complexity (e.g. developing a new synthetic fertilizer, a precision medical device, or an automobile) may not lead to concepts with high feasibility or likelihood of adoption. However, a co-design team with a mix of potential end-users/customers and designers with appropriate technical expertise may or may not generate concepts that are highly feasible, creative, and with a high likelihood of adoption. Expanded study is required to understand the effects of end-user/customer participation in design more generally.

Invariably, the performance of teams is a function of specific individuals as well as their collective interactions. It is expected that the results of this study are quite dependent on the individuals who participated and how they interacted with one another. Measures were taken to encourage positive team dynamics and active participation within teams. Exit surveys and facilitator observations were used as indicators of abnormal team dynamics that may have significantly impacted team performance – nothing notable was observed. While it may have been fruitful, it was not possible to document factors describing team dynamics such as social sensitivity of group members, distribution of conversational turn-taking (Woolley et al., 2010), or cognitive diversity (Kress et al., 2012).

5 DISCUSSION

This study was conducted in rural Zambia and aimed to examine how variable end-user/customer participation affects design outcomes. One final concept was developed by each of eleven design teams – three using a user-centered design approach; three using a co-design approach; and five using a user-generated design approach. The top two concepts (Concepts 1 and 2) in terms of rated likelihood of adoption were created by user-generated design teams (composed entirely of potential end-users/customers), and these two concepts were implemented by the partner enterprise in Zambia.

In this scenario, teams with high end-user/customer participation (user-generated design) correlated positively with concepts that rated highly in meeting the need, feasibility, and likelihood of adoption, and correlated negatively with concept creativity. Teams with less end-user/customer participation (user-centered design) generated concepts with mixed design outcome results, and teams with mixed designer and end-user/customer participation (co-design) exhibited the highest balance of creativity, feasibility and meeting the need, with a medium level of likelihood of adoption. This suggests that, if the goal is high adoption, one may consider high levels of end-user/customer participation in key generative design activities, such as ideation and concept selection. And, if highly creative concepts are desired, a high proportion of external designers may be advisable. Additionally, if a secondary goal is to build design capacity within stakeholders, one my place stronger emphasis on participatory design approaches such as co-design or user-generated design.

We recommend future work that explores the role of cultural and technical content experts – not just potential end-users/customers and external designers – in the design process. Additionally, it may be useful to develop a measure for co-design, particularly one that incorporates the multifaceted aspects of team diversity including team expertise mix and various types and degrees of stakeholder participation. We acknowledge the relatively small sample size of this study and that likelihood of adoption is difficult to measure reliably. Studies with larger sample sizes and alternatives for measuring likelihood of adoption may be considered. In other words, will high feasibility and likelihood of adoption ratings equate to high adoption? What stands in the way of concept adoption? A longitudinal study may be considered to better understand this gap.

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