Capability approach-based evaluation of a biomass cook-stove design

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What is the scope and responsibilities of design? This work partially answers this by employing a normative approach to design of a biomass cook stove. This study debates on the sufficiency of existing design methodologies in the light of a capability approach. A case study of a biomass cook stove Astra Ole has elaborated the theoretical constructs of capability approach, which, in turn, has structured insights from field to evaluate the product. Capability approach based methodology is also prescriptively used to design the mould for rapid dissemination of the Astra Ole.

Keywords: Capability approach, design evaluation, design life cycle, improved cook stoves.

Introduction

CONCEPTIONS of well-being are complex, multi-dimensional and individual. Predominant approach to well-being distinguishes between objective and subjective well-being[1]. The objective well-being considers externally assessed and approved, non-feeling-based features like access to mobility or low morbidity. Subjective well-being is an individual's personal judgement; thus, it is predominantly feeling based. In subjective well-being, criteria to discern desires resulting into material well-being and psychological well-being are difficult to comprehend. Estimating effect of product on well-being, which is the measure of ultimate success, becomes difficult due to these complexities in the conception of well-being.

Cook stoves provide an envelope to generate and transmit the heat from a fuel for cooking food. Cook stoves have multiple interlinks with the well-being and thus is an important topic of research attracting global attention and financial expenditure[2]. Traditional cook stoves, commonly referred to as three-stone fires, are inefficient but are flexible to operate on multiple fuels such as firewood, farm produce, cow dung, sawdust and coal. The rural population of India (67% of the total population[3]) has access to the farm produce and cow dung, commonly referred as biomass. Incomplete combustion of traditional cook stoves, resulting into indoor smoke, causes 2.2 million deaths per year[4]. Cook-stoves affect users multiple conceptions of well-being. Biomass cook-stoves ensure energy security due to guaranteed biomass availability in rural India. Health of user is negatively affected due to continuous exposure to smoke generated. The long hauls for biomass collection causes mental and physical trauma and presents risk of falling to animal and human predators. The time spent in biomass collection can enhance the well-being of biomass collector. Indoor smoke blackens the households affecting the beauty, in effect the social status.

Improved cook stoves (ICS) clear smoke through a duct pipe by naturally induced or forced draft and improve burning efficiency by improved utilization of generated heat. ICS improve well-being by reducing ill effects and retaining positive features of the traditional stoves. Liquefied petroleum gas (LPG) stoves are replacing traditional biomass stoves in households. LPG is a clean energy source; however, its price and availability questions its viability as a long-term energy source[5]. Distributional challenges in rural markets[6,7], further limit LPG availability. On contrary to this, biomass supply and distribution channels are well established. Ironically, users have not accepted the improved cook stove; even though the positive impact on well-being is evident[8].

Evaluation criteria to accept the product is thus complex to comprehend. On technical factors, most of the ICS's are successful, but not adopted by final users. An important question here is, 'whether design of the ICS is thus successful or not?'; 'Yes', if scope of the design is linked to technical success as out of 29 stoves evaluated in India, every stove is efficient than traditional stove and vent out smoke[9]. Product specifications are the measures of the product/service/technology success and thus the designer scopes the effort to fulfil these evaluation criteria. Understanding and questioning the adequacy of the basis to arrive at product specification is thus important. Narrow evaluation criteria may not achieve the aim of positively influencing the well-being of involved stakeholders. This study tries to answer a few questions such as, 'how can a product be evaluated in addition to technical performance? Can there be a theoretical basis to discuss the scope of design? Is it possible to structure this

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evaluation? Does an existing normative approach support this?

In this study, the improved biomass cook stove, Astra Ole's evaluation explicates the theoretical underpinnings. The basis of selection of the case study is Shridhar Lokras's and H. I. Somashekar's three-decade long experience in dissemination of the stove and the holistic understanding of the product's ecosystem. Interactions, focus groups and individual interviews during product design and dissemination are the basis for the analysis of the Astra Ole. The inadequacy of existing methods of product evaluation and the necessity for an alternative normative framework was evident during the fieldwork.

The capability approach (CA) is an influential normative framework to evaluate well-being. Current CA-based evaluations of products/technologies are not located within the prevalent design perspective but from a philosophical perspective. This study brings the constructs of CA into the design as practised and presents a CA-based yet design-oriented holistic evaluation of a product. Suggested design methodology drastically widens the designer's window of perception. Perceived differences between traditional and CA-based design perspectives are highlighted in this study.

Astra Ole

Astra Ole is a scientifically designed biomass cook-stove developed by the Centre for Sustainable Technologies (CST), formerly Application of Science and Technology for Rural Areas (ASTRA). The CST was established (as ASTRA) in 1974 at the Indian Institute of Science (IISc), Bengaluru[10]. Ole means 'stove' in Kannada, a local dialect of Karnataka. The technology that originated in 1984–85 has the highest efficiency (45–50%) as calculated on a standard water-boiling test and is one of the best stoves available[9]. Based on field tests, the advantages are: reduced fuel consumption (more than 50%), reduced cooking time and smoke-free indoors due to a natural air draft through chimney.

From a traditional product evaluation perspective, the Astra Ole is a successful product for many reasons: (1) Dissemination of approximately 1.5 million stoves in the time span of 1984 to 2003 (ref. 11), and this number is growing. (2) The technology acceptance rate is approximately 60% (ref. 11). (3) The product consistently meets the technical performance of increased efficiency, reduced cooking time and removal of indoor smoke. These numbers are impressive but considering the actual potential of technology (predicted to be 235 million households where overall ICS has reached only 9–13 million stoves[3]) and need, these numbers should have been much high. Another important point is, in most cases, the government schemes pushed the dissemination. Only two of the six reasons for low demand for biomass ICS are product-related and one is technology-related[12]. Technical performance and cost benefit are necessary yet insufficient for product evaluation. Existing normative approaches such as appropriate design, universal design deal with these issues but fail to provide any methodological support to the designers to discern the factors outside technical design[13–15].

Design: a capability approach-based perspective

The capability approach: constructs and design

The capability approach is a broad normative framework to evaluate well-being and justice[16]. Normative frameworks help in forming the 'value judgments' for perceiving a given situation and conceptualizing the future. In CA, capabilities refer to effective options for individuals to be and to do, to live lives they value[17], and serve as a measure of well-being. In the literature, CA has been applied to technology to establish links between technology and capabilities[18], explore design as capability[19], for a capabilities-based evaluation of technology[20,21] and to comment on ethical aspects[22]. These attempts lack the perspective of design practice and thus present difficulties in guiding design. This section presents the constructs of CA from a design perspective and elaborate capabilities as the basis for design evaluation.

The purposeful, goal-oriented 'thoughtful action' to provide solution to end users problems is the design[23]. In its most generic sense, Simon[24] defined design as a process of changing the existing situation into a desired situation. To interpret the existing situation and a desired situation operationally, one must know the problems in the existing situation and the notions of desirability. This requires normative judgements, which in turn decides the aspects considered in the existing and desired situation. Conceptualizing the existing and desired state in terms of capabilities as matured conceptions of needs fulfilment broadens the evaluative paradigm. Current discussion on CA constructs is the perspective of the social sciences

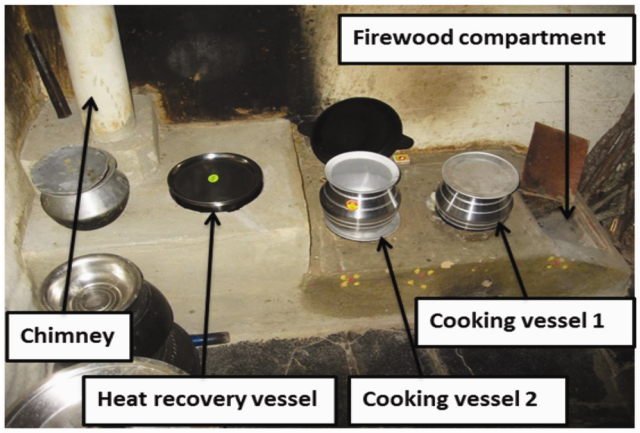

Figure 1. Description of Astra Ole.

and developmental economics. In the following section, we interpret the CA constructs from the design perspective.

Importance to ethical individualism[16]*:* The basis of ethical individualism is that 'Individuals, and only individuals, are the ultimate units of moral concern'[16]. Identifying target users is important for design to improve their well-being. Identification of capabilities is with specific individual or group and not with generic. Inclusion or exclusion of certain users affects design. CA insists that the effect of evaluation should be for a specific individual that are most disadvantaged. In the absence of sufficient measures, benefits for the poor or most disadvantaged, will always be 'hijacked' by the non-poor or less disadvantaged[25]. In the case of cook stoves, the reduced volume of biomass may causally improve a family's livelihood; for example, saved biomass means less time spent on collecting biomass leading to additional wages earned by women. Additional income positively affects the family as a unit of analysis. Woman as a unit of analysis may end up working harder, affecting her health. Over packed daily schedule may negatively affect the mental peace, reducing the individual well-being. Ethical individualism in 'design for capabilities' compels to identify the most disadvantaged individual or group as the specific owners of the capabilities, and tries to evaluate their well-being through design.

Importance to freedom: In CA, freedom manifests on two levels: (i) Freedom to choose what one wants to be and do based on one's conception of life[16]: The construct linking the *be*ing and *do*ing to conception of life is something more abstract than formulating the well-being as access to objects of utility such as a car, television or mobile phone. Understanding the capabilities demands deeper holistic understanding of need, which is not comprehendible without a real dialogue with the users. Freedom of users to choose capabilities ensures in-depth, fair usage of participatory methods, which are the tools often used to confirm the designer's bias[26]. Most cook stove users are poor. This construct graduates the financially poor cook-stove users from being needy, help seeking recipients of aid to thinking rational individuals[17], whom the designer should serve through his profession.

(ii) Freedom to choose from available options[16]: CA values the plurality that individuals needs and resources differ[27]. Acknowledging this plurality, a single or a small set of options cannot fulfil the population's requirements for life. Poverty penalty[6] is increased vulnerability due to high dependency on few resources[28]. In such situations, capabilities as the freedom to choose from feasible options serve as better evaluation space for the products[29]. While multiple options have environmental implications, few options affect the sustainability of the population. This aspect needs careful context immersion. LPG is the best technical solution for most problems, including smoke and decreasing the efforts of women. Irregular, unpredictable distribution and price affect the poor population's complete dependency on LPG as single energy source. Most households expand their options by having both LPG stove and biomass cook stove. A biomass cook stove's viability expands the capability space and, smoke and inefficiency diminishes the capability space.

Distinction between means and ends[16]*:* For a certain activity, 'ends' are the ultimate goals while 'means' are the methods/routes/tools deployed. The straightforward ultimate ends of well-being for physiological needs become 'fuzzy', conflicting and 'messy' as we ascend Maslow's hierarchy[30]. CA distinguishes means from ends and thus tracing each 'mean' level capability to 'end' is necessary in CA. Ends, as ultimate goals, drive lower-level beings and doings. For example, improved cook stoves are ultimately required for an increased livelihood and good health achievable through saving of biomass and smokeless indoors. Without increased livelihood as an end, a cook stove, which saves biomass, is as undesired as one, which does not save. In regions with abundant biomass, saving biomass does not save cost or generate profit for the user. Users in these regions will not accept ICS if an increased livelihood is the only final motive.

Distinction between means and capabilities[16]*:* Capability is not equal to availability of a 'mean' as fulfilment of capabilities requires multiple means. In absence of appropriate technical knowledge, specific fuel, inclination towards use, etc., owning an improved cook stove is not equal to the capability to use it. Existing normative approaches equate means to benefits. The use of tele-centres in rural India failed due to the absence of a service network and social stigmas[31]. Capabilities are beyond means.

These constructs are the basis of an alternative perspective for traditional design.

Generic evaluation of Astra Ole through CA

Variation in culture and behaviour within small geographic distance is common in target BoP market of Astra Ole. This evaluation is specific to region and population in northern states of Uttar Pradesh and Madhya Pradesh in India. This section compares traditional evaluation and CA-based evaluation in succession.

Product evaluation: ethical individualism and identification of target users

Evaluation criteria in traditional methods are generated based on the directly conceivable characters of target population, context and product like economic status (to decide cost targets), availability of space (to decide size),

cooking habits (to decide the functionalities), technical bounds like for content of harmful gases (to decide the fuel efficiency, combustion characteristics, etc.). The information collected results into the technical specification.

According to CA, target population to collect this data is not homogeneous. Identifying the most disadvantaged in the target population is important. Technical or monetary constraints may not allow design of the product to serve some extreme disadvantaged population, but consciously excluding such population is important. According to CA, there are categories within disadvantage and its identification is not straightforward. Technical features, as in traditional methods, are simplest starting point for this. The evaluation through the CA constructs like importance to freedom, distinction between means and ends, and distinction between means and capabilities provide additional criteria, which should be included in cyclic manner. Disadvantage criteria help in finding the most disadvantaged as well as most advantaged individuals from target population. Few disadvantage criteria for Astra stove are: (1) Access to biomass (land ownership, cattle ownership – cow-dung cakes as source of fuel, distance from forest, economic ability to buy firewood), (2) Access to space (size and aspect ratio of kitchen), (3) Access to information (TV with multiple channels, newspaper, computer, Internet, electricity, etc.), (4) Gender (patriarchy, role of women in decision making, occupations of women, etc.), (5) Social structure (caste, reservations, subsidies, government schemes, etc.), (6) economic status (below poverty line), etc., (7) house type (reinforced cement concrete – permanent, traditional house with temporary shade as kitchen, huts – transitory accommodations for nomads or for very poor category). According to ethical individualism, the evaluation basis should be the fulfilment of capabilities for most disadvantaged people in these categories.

Contextual examples from field: (1, related to disadvantage category – gender). In Uttar Pradesh the youngest daughter-in-law is responsible for cooking. In larger families, firewood and availability of cow dung cakes was not a constraint. In such families, even though Astra Ole could save biomass and avoid contact with smoke, the speed of cooking was most crucial for the person responsible for cooking. For achieving best efficiency at normal cooking speed, Astra Ole uses controlled combustion. Traditional biomass stoves can achieve increased combustion by increasing the biomass burnt resulting into drastic reduction in efficiency. Astra Ole was beneficial for the whole family due to saved effort in making cow-dung cakes (a type of fuel) and exposure to smoke. Relative slow cooking rate was disadvantageous due to time burden in morning rush hours. (2, related to disadvantage category – access to biomass, economic status). Daily labourers buy the biomass by bartering their labour, as they do not own land. This will be the most benefited user group by this product. In Madhya Pradesh, the higher middle class people are driving the demand for stove due to their ability to bear the initial stove cost. Their motive is not to save biomass but to save their newly constructed houses from blackening due to smoke. Recent transition from traditional mud houses to reinforced cement concrete (RCC) houses and stricter norms by government to control electricity pilferage (electricity being source for highly inefficient cook stoves) drive this demand. Though the program is impressive in absolute numbers, the benefit has not yet reached the most disadvantaged group.

Product evaluation: importance to freedom

Freedom to choose what one wants to be and do based on one's conception of life and needs analysis of primary users: Methods like participatory design, ethnographic studies can provide this freedom to stakeholders. Individual bias and technology bias negatively affect this desired outcome[32] in absence of normative framework like CA. Defining the success in terms of fulfilment of capabilities provides true freedom to the users to position the product in their conception of life. This can provide the designer far deeper insights than regular product-centric methods.

Freedom to choose from available options and needs analysis of primary users: Technology diffusion studies try to understand acceptance of a product without understanding why it is required in a given situation. Assuming the necessity of the product and then evaluating 'why' the users failed to accept it?, is technology bias[32]. In traditional methods, the perception towards other feasible options to fulfil a function is known as threats. The main idea is to monopolize the market to increase the number of products sold. CA believes that multiple individuals have multiple desires and own multiple resources. Single product may not suffice heterogeneous stakeholders. In CA-based perspective, a given design can be a valuable option among multiple options to fulfil the given capability. Though economic feasibility needs a minimum volume, according to CA multiple means can co-exist if they are necessary to fulfil the conception of good life. This results into a respectful vision towards looking at the existence of competing technologies and originates an unbiased deeper understanding of current ecology, which could be advantageous.

Contextual examples from field: Many users of the biomass stoves have retained the traditional stove as well as LPG. LPG provides a capability to access the cooking energy in few seconds and for short runs like making tea. Biomass stove is dependable, cost effective and imparts desired flavour to the food. Inability of biomass stove to fulfil quick and short energy demand is not a failure in CA-based evaluation, but is complementary to LPG stoves as it fulfils different desired capabilities.

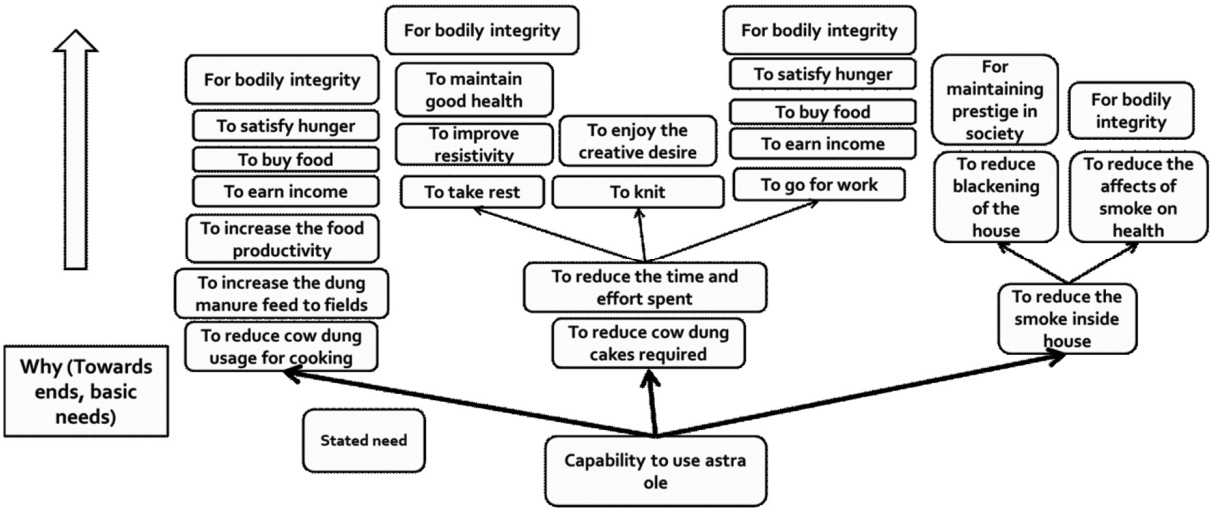

Figure 2. Distinction between means and ends for a 'capability' to use Astra Ole.

Understanding aspects like this reduces designer's burden in covering requirements for which alternative products are available.

Product evaluation: distinction between means and ends

In traditional design, the primary function is an end or goal. In case of ICS meeting the primary functions could be saving biomass, ducting the smoke out and saving cooking time. Any ICS design meeting these requirements could be successful. In CA, each stakeholder is involved in the product life to fulfil individual capabilities as ends that are not explicit.

In CA evaluation Astra Ole's biomass saving and effectively ducting smoke out in test environment is not the end. The success criteria should be the user's capabilities. The technical characters are just enablers for the user's capability. Ascertaining distinction between means and ends avoids assumption that users are interested in technical performance alone. Upward extrapolated of means towards ends could be achieved by asking the 'why' question (see Figure 2). Asking the 'why' question is an established method for deeper understanding of needs[33]. In traditional methods, the conception of need is not as rich as capabilities as well the purpose of the enquiry is to come up with technical specifications, which limits the informational outcome of the exercise. Identifying the higher level means through distinction between means to ends and then further understanding each mean by distinction between means and capabilities present much larger landscape than traditional methods.

Contextual examples from the field interviews list one level high ends as (without any order of importance) – to avoid eye/lungs problems, to save biomass, to save house from blackening, to gain prestige in community as users of improved stove and to save time. Upward extrapolation of each higher-level mean should be continued until some category of need as in Maslow's[30] hierarchy is reached. Asking the why question to each capability traces the ends of each mean. Answer to higher-level capability of 'to save time' is given here as an example. Women were interested in capability of saving time for spending time with children/friends, taking rest, pursuing hobby, etc. This gives deep insights into their desires towards life and CA cautions designers that fulfilment of these higher desires is crucial for the acceptance of the product.

Product evaluation: distinction between means and capabilities

Distinguishing between owning an Astra Ole and 'capability of being able to use the Astra Ole' essentially requires listing all the necessary resources. Being capable of using Astra Ole in CA means being able to access, use, repair and discard the stove. This distinction extends the design ownership to the whole life of the product, pursuing designer to think of each life cycle phase during the technical design part. Design methods acknowledge the importance of these aspects but generally leave them to the discretion of marketing team. Traditionally, finalization of the product design precedes dissemination and service decisions because the scope of design is limited to technical design. Designing technical aspects based on needs of stakeholders other than user and for later phases of product life is uncommon. Use of design for manufacturing or assembly is only to enable to finalized product concept for manufacturing. Design for capabilities brings these aspects during the conceptual phase of product, which imparts far more flexibility for possible changes based on stakeholders inputs involved in later phases of product life. In informal market, methods/tools/processes

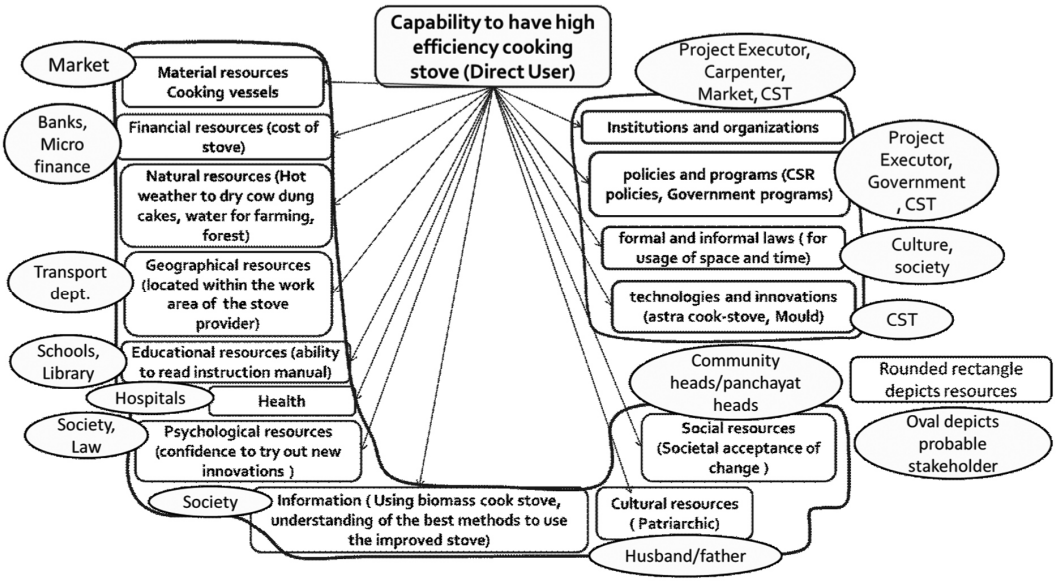

Figure 3. Construct of distinction between means and ends; adapted from ref. 20.

of manufacturing/distribution/recovery are non-standard and change along the geography and thus this flexibility in design is crucial.

Kleine's choice framework[20], as an exhaustive checklist for possible resources, is used to distinguishing means from capabilities (Figure 3). Identifying resources for a given capability is 'downward' extrapolation. Downward extrapolation of each capability, including the ones identified through upward extrapolation, ensures availability of all the crucial resources. The capability will be unfulfilled in absence of a crucial stakeholder linked with a crucial resource. Identifying and analysing their motives in involvement of product as capabilities can investigate the possible absence of such stakeholders.

Contextual examples from field: Figure 3 extrapolates the resources required for a user to have an Astra stove. One interesting resource to mention is not easily comprehendible social resource. In Uttar Pradesh due to low rate of literacy society was not receptive of new ideas, but in Madhya Pradesh society could easily accept the new stove. Cultural factor like patriarchy affected the interaction of the male interviewers with females.

Crucial challenge/shortcoming in the design of Astra Ole as capabilities was in the phase of manufacturing. From the inception, manufacturing of the stove was in brick and mortar. Skilled mason is necessary for construction of the stove as efficiency of the stove is the resultant of dimensional and geometric accuracy. In rural India, skilled masons are in demand as building stoves pay less than constructing houses and thus semi-skilled or unskilled labour build stoves. Inability to achieve dimensional and geometrical accuracy due to lack of skills results into suboptimal stove performance. Training, quality control and retaining trained labour is a big challenge. Lack of capability of constructing Astra Ole with unskilled labour hampers the capability of using Astra Ole in the following ways: (1) unavailability of stove, (2) no fuel saving, (3) substandard looks and (4) incomplete smoke removal. According to CA, failure to addressing the unavailability of skilled labour is the failure of design itself. Simplifying the stove geometry or designing a simplified stove construction method could be the possible ways.

Design of a mould for rapid dissemination of Astra Ole

Deskilling construction method without compromising on desired dimensional stability and structural strength is the main design challenge. The method of rammed earth achieves a desired shape by ramming the proportional mix of soil, sand and cement inside a mould. Sand from fields and soil from nearby streams constitutes the major volume of the structure. Reduced usage of the cement further reduces the cost. Selection of rammed earth as new method of construction was thus based on the above suitable factors and structural stability and strength.

Designing a mould with complex, contoured shapes with crucial dimensional accuracy was a challenge. In the mould design, usage of CA-constructs has critically widened the design scope (Figure 4). The construction of mould is in wood due to low weight and price, availability, workability and desired strength allowing local entrepreneurs to initiate the stove construction business with low initial investment. The intentional simplicity of structure is to reduce the mental effort in assembly and disassembly to impart the capability to use with least training. The mould has three tiers similar to visible characters of the stove to remember relative placement, easy manoeuvrability in

cramped stove construction sites and to facilitate transportation between sites. It also provides the freedom to choose chimney position to suit various rafter positions and 'vaastu' considerations (traditional Indian prescriptions of planning a house) in the mud houses of rural India. The mould assembly includes templates for accurate dimensioning. Design has specially considered the working conditions on site, like lack of sufficient light, presence of sand/dust, cramped working area. Fastening of small and loose mould parts (other than fasteners, as they are available in local hardware shops) to the bigger parts ensures that they are not be misplaced or left behind at the work site. According to CA, manufacturing and service are included in the scope of design. Simplification of all angled wooden joints to lap joints avoided usage of any special tools that might not be available in small towns. Conscious usage of easily available local material for joineries has avoided any special parts. Manufacturing and servicing of mould is thus possible in the smallest town of rural India. A match between probable achievable 'ends' through the stove business and desired 'ends' of mould buyer was crucial in mould design to ensure his/her involvement in the dissemination programme. As an extension of design, promotion of the mould-based construction of Astra Ole as a business and training is under design.

Inferences from CA-based evaluation and design

CA perspective towards design of biomass cook-stoves

Astra Ole is among the best stoves in India assuming the scope of design is limited to efficient, ergonomic, functional stove that vents out smoke[9]. CA-based analysis has extended the responsibility and scope of Astra Ole design. The following discussion highlight a few instances of extended responsibility and scope.

Figure 4. Construction of Astra Ole using mould.

Old and new manufacturing process of the stove targets 5–6 years of stove life. There are user sub-groups who has temporary houses/kitchens, needing one-year stove life. Astra Ole does not have a suitable low strength, low cost and low life variant. Though designers can always claim that the stove specifications do not include these demands and thus the stove design is perfect. CA widens the responsibility of design to include these requirements, as this results a considerable population away from benefits of the ICS.

Different regions showed different interest in stove based on their desired ends. In localities with permanent modern houses with abundant biomass availability, user's desire stove for effective removal of smoke to retain the beauty. In areas with abundant firewood and temporary house types, stoves are undesired as they had outhouses as kitchens that are repaired frequently with local inexpensive material. Health impact of the stove is not instantaneous but long term. Very few customers accepted the stove for its health benefits as smoky kitchens is an accepted reality. In areas of low biomass availability, people accepted the stove due to biomass saving. Designer's scope of work, according to CA, extends in ensuring the ends which people wish to achieve. Educating women about the indoor smoke-related health hazards require collaboration with the government hospitals. These are out of scope of the technical design of the stove.

CA-based approach ensures identification of non-technical resources like social acceptance to new things which in turn depends on the educational levels. Target young people discontinued stove manufacturing as vocation due to the social pressure of not following a traditional vocation, as stove building was a low status vocation. This hampered their marriage prospects. Branding the stove as scientific, high esteem product may solve these problems which, according to CA, should be under the scope of design. Downward extrapolation of the capabilities help in identifying the resources which, in turn, identifies stakeholders for the whole product lifecycle. Each stakeholder's interest in stove as capability helps to understand the stakeholder's basic motive in involvement in product lifecycle. Young stove builder quitting the stove making is not linked with the standard matrix of evaluation, remuneration, as it is competent to other vocations.

Reaching at such intuitive insights becomes difficult in absence of the structured methodology[34]. CA can provide such methodology. This transforms stereotypical designer from product creator to a thinker who, irrespective of technical product involved, identifies the extent and areas of effort to achieve the well-being of the stakeholders. Different departments involved in development of product like engineering, marketing, management, distribution, etc. then can have a unified goal to achieve, which results into synergy. Capabilities thus provide a unified goal for all the actors in reaching towards the well-being of stakeholders.

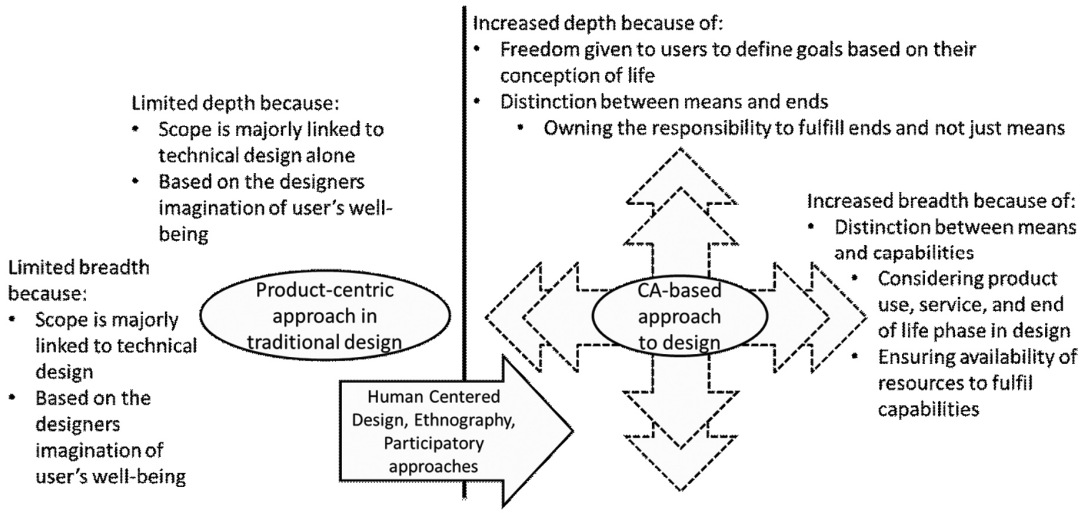

Figure 5. Traditional design approach versus CA-based design approach as a continuum.

Insights on design from a capability's perspective

Predominantly, concern for design is fulfilment of functions through a product[35,36]. This is rooted in the history of design as making artefacts for personal use and then for industrialization[36]. Designing functionally sound products has always been the focus of the product design, which is necessary but not sufficient in the case of BoP population. In industrialized economies, stakeholder behaviour is predictable because of market-oriented motives like 'maximizing the profit, legitimizing the industry and following acceptable organizational culture'. Contrary to this, markets in developing countries are not structured. Societal values, cultural aspects and emotions govern the contracts in informal market, as the market and society boundaries are fuzzy[38]. Thus, simulation of each phase of the product life cycle using the specific stakeholders in the specific context for a specific product life stage is necessary. The scope should then extend beyond just technical aspects of design. Scoping design to fulfil the technical aspects is sufficient in developed markets but may not be suffice for BoP. Like the adoption of products from developed markets failed, adoption of product-centric design also may fail in BoP. Currently, product centricity is acknowledged in both practice and education[39], in design practice[40–42]. The reason can be attributed to market-orientation as against the social model of design[13,43,44]. Though there are attempts like human-centred design (HCD) methods, participatory approach to address product-centredness as a continuum towards CA-based design (Figure 5). Designers' bias towards own beliefs and probable outcomes make use of HCD methods, like ethnographic studies or participatory design, less effective[26]. Capabilities as conceptions of well-being of stakeholders have the better chances of avoiding these biases; though further studies are required to validate this aspect. HCD methods structurally do not scope design for ensured well-being through design that are achievable through CA-based approach. The technical success of design is crucial but not sufficient unless the product positively affects stakeholders' lives. Only referring to technical aspects as design is more harmful in underdeveloped markets such as BoP. Designing for capabilities, normatively, avoids the unjustifiable importance attributed to product, treating it as merely a means to fulfil the capabilities, expanding scope of design to achieving the well-being.

Conclusion

Normative approach towards 'what design should aim to fulfil?' is necessary yet not explicit in current design methods and methodologies. This article compares the predominantly normative framework towards looking at the design and the new normative framework of capability approach. The capability approach widens the scope of design and compels design to be more responsible. Design for capabilities takes the responsibility for meeting the 'end' users wish to fulfil through the product and methodologically extends the ownership of the design to the full life cycle of the product. Ownership of meeting ends requires development of whole ecosystem. Design for capabilities brings a lot more under the umbrella of design that traditional design now considers which might be overwhelming to the traditional designers in the absence of structured methodology.

Notions of design as capability are difficult to understand without a methodology and a working example covered in this article. The case study of Astra Ole has that complexity to elaborate the methodology. Additional example of design of mould has shown the usage of CA-based methodology in a prescriptive manner.

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