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ECONOMIC DEVELOPMENT AS DESIGN: INSIGHT AND GUIDANCE THROUGH THE PSI FRAMEWORK

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Abstract

Economic development is aimed at improving the lives of people in the developing world, and needs to be carried out with design at its heart, but this has often not been the case. This paper first reviews dominant approaches to economic development including the use of subsidies or the creation of markets and demand and the testing of initiatives using randomized control trials. It then introduces 'development engineering' as a representative engineering design approach to engineering and technology in development before presenting the view that successful development needs to involve continual learning through innovation in context. The PSI (problem social institutional) framework is presented as a basis for guiding such development as a design activity, and its application is illustrated using examples from India of the unsuccessful introduction of new cooking stoves and then both successful and unsuccessful approaches to rural electrification. A 2-level approach to PSI is taken, in which the lower level represents daily operation of communities and the 2nd level represents the development project including addressing misalignments between the different PSI spaces and levels.

Keywords: Design theory, Social responsibility, Participatory design, Economic development

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1 INTRODUCTION

In his book "The Sciences of the Artificial," Simon proclaimed that any person who is involved in changing the state of affairs to a new desired state is engaged in design (Simon, 1996). Even though Simon pursued the idea of the science of design as a decision making and problem solving process, he also alluded to social planning as an activity with evolving goals that may not be amenable to his original idea of problem solving. As it so happens, the vast majority of problems in the developing world involve a combination of the introduction of technology and social planning. In this paper, we take an approach to design that is centered more on the social interactions and socio-economic context in designing and on solving the problem that evolves over time.

Economic development, in particular in the developing world, is an activity aimed at changing and improving the lives of the people, which makes it a design activity and would point to design as a vehicle of economic development with engineering design at its heart. However, the reality is not so simple. Many well-intentioned engineering projects fail to deliver the hoped-for improvements and many development researchers overlook design as an agent of change that can be directed to deliver improvements and privilege policy change or social change in engineering projects.

This paper compares three possible approaches to economic development: the current dominant economic models of development, an engineering perspective on development, and our expanded notion of design that includes the problem that is addressed and its social and institutional context together in a single framework called the PSI framework. To prepare the reader for the comparison, we first provide a brief overview of the dominant strands of thinking in economic development. We also identify the lack of engineering content in the discourse on economic development in general. Further, we make the case that, even when adopted, current engineering design approaches to technology and development are inadequate in addressing development problems. We use our framework to explain failures and successes in economic development projects that have involved technology, using as examples cases from India of biomass cookers and rural electrification.

In the paper, we view engineering as an activity that has a specific goal to satisfy a need or desire, and that it may involve adapting an existing product or a service or creating new technology that is situated in a particular social and institutional context for a specific audience either through a market or as a public good. While the components of the designed artefact or service may be captured as quantifiable requirements, the system and its behavior in context will transcend the purely technical requirement of the components themselves.

2 ECONOMIC DEVELOPMENT AND DESIGN: DOMINANT VIEWS

In the vast literature on development, there are different strands of development theories and philosophies. The dominant ones come firstly from Jeffery Sachs (2006) and his adherents, whose goal of eliminating poverty is through distribution of funds to overcome the poverty trap, and secondly from William Easterly, who advocates creating conditions for markets to emerge leading to demand for human labor leading in turn to alleviation of poverty (Easterly, 2008). In contrast to these top-down theories a new bottom-up model of development promoted by Banerjee and Duflo (2011) uses randomized control trials (RCT) as a way to understand the behavior of the poor for the creation of targeted policies to address specific problems such as deworming of children in Africa (D'Aoust, 2014). RCT is criticised as reductionist, and failing to take into account the sociological, economic and psychological needs and capabilities of the population that is targeted for intervention (see Woolcock, 2013; Reddy, 2012). While RCT can provide internal validity, it does not provide external validity in terms of functioning services and products (Woolcock, 2013). All of economic development is about changing the multi-dimensional state of the world for the poor or underprivileged to a state where poverty is not a handicap in their functioning as productive citizens. More generally, while all of these approaches aim at changing the state of the system through interventions, they are often viewed as design or engineering problems not situated in context but as requiring transfer of dominant designs from developing countries (Heeks, 2002; Tongia, 2006). An engineering and design perspective requires internal validity of the methods to be aligned with the external validity or performative aspect of the artefact that was designed; that is often the missing link in development efforts.

Albert Hirschman, a non-conformist economic thinker and development economist, questioned the logic of self-interest capitalism as the path to general welfare (1977) by arguing that the model of capitalism that is based on rational calculation was not even consistent with Adam Smith's appeal because it ignored the role of sympathy, honor, friendship and collective interests in the rise of modern form of capitalism. Based on his vast experience in working in development projects, Hirschman deplored the idea that, from outside, using the model of self-interest, one could help people to become economically developed. He rejected the 'one-size fits all' models of development and taking up one problem at a time as that would suffer from the problem of interdependence (Hirshman, 1977). He contended that it is only through experience, trial and error and creativity that we encounter and overcome the unexpected. For that reason, development problems have to be solved with local communities, taking into account their knowledge and aspirations, and not through externally calculated rationality. Such rationality apparently renders the problem easy, removes doubt and experience and makes it as if all problems are the same, it may thus erroneously be seen as a 'silver bullet' to make lives better.

3 ENGINEERING AND DEVELOPMENT STUDIES

In a recent article by Robbins et al. (2016), the relationship between engineering and development (or lack thereof) is explored. In their thorough analysis of the history of development studies, they trace the thinking in development from its origins in 'development science', which assumed that development occurs solely through science and that the promotion of science in developing countries would lead to development. This is based on the prevailing post-war belief (or myth) that the path to development is from basic science to applied science.

Robbins et al. point out that engineering has been largely absent in these discussions and one would wonder why technology and innovation have a place without attention to engineering and design. This perspective is only meaningful if one believes that development is the transfer of technology and innovation from the developed world to the developing world, in which case economic development is nothing but empowering the people of developing countries with some substitutions of technology that already exist in the developed world.

Recently, Development Engineering (DE) is being viewed as an answer to the need for a framework for the role of engineering and technology in developing societies. As Robbins et al. (2016) point out, the goal of DE, as envisioned by researchers at UC Berkeley and other practitioners, is “applying economic and engineering research to the problem of poverty” (Nillson et al., 2014). However, there is no clear definition of what DE is and what its goals and focus are beyond technology and innovation transfer; the role of design in DE is also not clear.

Engineering design itself is also often very narrowly conceived, most often again with a focus on technology. It has been expanding the scope of the viewpoints that it acknowledges, for example by the explicit acknowledgment in the form of 'design for X' of manufacturability, recyclability and other 'ilities'. This extension has led to the emergence of life-cycle engineering approaches, that consider the impacts of the whole life of the artefact from conception to disposal, but the focus remains technical and does not include the socio-economic context, processes and institutional structures.

In addressing technical aspects, the current dominant discourse in engineering design is also often limited to methods and technology development for the use by the mass customized consumer from a physical and digital product perspective. Such an approach is not feasible for all products that are public, private and common pool resources for a population of in the order of 1.2 billion people as in India. Transporting technology in a non-contextual manner, propagating the idea that what is good for us is good for others, is hubristic and imperialistic.

It is noted that only 15% of all 'information technology for development' projects succeed, all others are partial or total failures (Heeks, 2002, 2008). Recently, Toyama (2015) makes the observation that technologies are not the panacea to development unless applied along with social and institutional change. The most common set of failures that have been catalogued in the literature have assumed that technology would work irrespective of context and can just be 'dropped in' for people to use or managed with top-down planning without any concern for the local needs/participation, narrow perspectives (both macroeconomic and microeconomic) and ignorance of history and social customs. These examples illustrate that for any theory of change, “the intent of the design” has to be technological, social and institutional. Unfortunately, this continues to be ignored because of professional practice that is present with its biases, history and economic ideology.

Engineering design is typically based on existing products as a means to reduce risk, cost and effort in product development. New technology is typically introduced into existing technology in a controlled manner, after it has been developed either in supplier companies, in R&D departments or in universities and slowly matured to a point that it can be brought into a product at an acceptable risk. In the development literature, the distinction between engineering innovation and product development is not drawn up clearly. Product development processes are design processes, which are characterized by a co-evolution of the problem and the solution whereas R&D style engineering often pushes the technology. In design processes there is a clear understanding that the needs of users need to be understood and responded to in a product, even though many processes are still looking to find the solutions in a refinement of the current technical solution. Product development also has numerous methods and approaches, such as platform architecture or customization, which could usefully be deployed in an international development context when negotiating the boundary between designs created in the developed world for the developing world, but also in the developing world for their own use or for export.

If we have learnt something from being engineers and designers, it has to be the lesson that we solve problems by combining our and others' experience in the context of their lives that empower them and sustain them in the long run. This requires not just the artefact being designed, but also the social composition of experiences and capabilities and the creation of new institutional mechanisms that is reflexive to respond to the unexpected, for creativity and innovation to blossom and not be crushed by a unified, sterile model of development.

Engineering is not just the design of innovative artefacts, it encompasses design, manufacture, installation and maintenance of sustainable solutions that produce value for society in the long run. Engineering is not just about creating knowledge for the sake of knowledge as is claimed by the logic of science, it is about achieving some goals that address social needs and is transdisciplinary, where the theory of the artefact that is created is the theory of its functioning in a socio-technical context (Monarch et al., 1997; Vincenti, 1990). It requires trial and error and is contextual and confronts the unexpected with creativity and innovation. Engineers with their devices not only create change in the appearance of an artefact but change the nature of routines of people in their daily lives, social interactions and institutional structures in which they function. They are subject to constant revision and subject to changes in context and at times beyond context due to arrival of new technologies. They change the context and the context changes them.

This was exactly Hirschman's view of economic development: a fluid, complex adaptive and reflexive approach that continually learns and corrects itself through creativity and innovation in context. It is context-sensitive and explains that unexpected situations require a response that is creative and innovative. Both are complex, adaptive and reflexive in nature that acknowledges temporary closures and the presence of 'known unknowns' and 'unknown unknowns' that appear in unexpected forms.

To address precisely the complexity of engineering design in context, we adopt a framework that extends it to address the necessity for a holistic view of designing. We elaborate on this framework in the next section.

4 PSI FRAMEWORK

We have seen that design is a complex activity that takes place within a rich context of interacting conditions. In an attempt to understand these conditions and to use this understanding to inform design activities we have created the Problem Social Institutional (PSI) spaces theory of design (Meijer et al., 2014; Reich and Subrahmanian, 2015, 2017). The motivation is to bring the diverse influences that impact upon design – economics, engineering, management, psychology and sociology – together in model that is rich enough to encompass all of these influences (and more) but also simple enough to be useful. The model poses questions about three spaces of design as follows:

- In the *problem space* the question is asked "what is being designed?" This space describes how engineering, marketing, R&D, the sciences and other disciplines come together to formulate the problem to be addressed and to transform it into a designed artefact.
- In the *social space* the question is asked "who are the people who are stakeholders in the design?" Exploration in this space aims to understand the motivations and aspirations of those involved in the artefact – from designers through users to maintainers and suppliers.
- In the *institutional space* the question is asked "what is the institutional context in which the design is conceived, implemented and operated?" Understanding this space allows economic, managerial,

organisational and political contexts – e.g. the influence of the involved companies and national and local organisations – to be understood and that understanding applied in the design process.

Each of the spaces, P, S and I, is further characterised by several dimensions. These are described in more detail in (Reich and Subrahmanian, 2015), but in summary:

- In the P space the *disciplinary* dimension describes the disciplines that are required to understand and respond to the problem and their relationship with each other; the *structural* dimension describes the way the problem and artefact space are decomposed in order to manage the complexity of the design task, and the *knowledge* dimension describes the knowledge available and needed to address the design task.
- In the S space the *perspective* dimension describes the diverse social viewpoints that are brought to bear on the artefact, and their interactions with each other; the term *inclusion* is used to describe the extent to which the social space is closed or open to multiple perspectives; the *capabilities/skills* dimension describes the participants' attributes needed to execute the design.
- The I space represents the rules, methods, procedures by which all the participants will be designing the product. In this space, the *ties* dimension describes the connections between the actors in the social network designing the artefact and their consequences for the design. The *knowledge accessibility* dimension describes how those actors can access the knowledge available in the various participating groups and organisations. The *institutional complexity* dimension describes the rules, culture, procedures and other formal and informal organizational structures.

In all the spaces, a change in one space often triggers change in the other spaces. For example, bringing more perspectives or capabilities in the social space may lead to defining the problem better, not only in more detail but also with entirely different focus. This may lead to a more complex or simply better solution in the problem space. In turn, understanding that the problem is complex, requiring a complex solution, may lead to using additional procedures to tame this complexity in the institutional space. In contrast, if a complex problem requires a quick solution as part of the problem definition, it may not be done by the organization if its processes and rules do not allow for cutting corners. In the terminology of PSI, the spaces need to be aligned. Failures and successes are closely tied to the alignment of spaces, as we will illustrate using the following examples of attempting technological change in a developing country context. Misalignments that arise due to various changes must be handled by redesigning the PSI spaces. This is best represented by a 2-level PSI framework where the lower level represents the daily operation of the organizations, community or an extended context and the 2nd level represents the development project including addressing misalignments. In the 2nd level PSI, the problem framing P' involves all P, S and I spaces below as shown in Figure 1. Since solving the misalignment is a design problem, it is clear why it requires its own PSI representation.

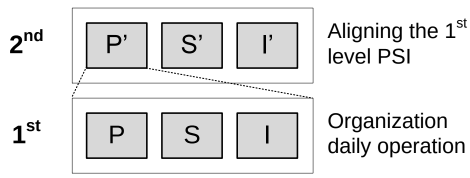

Figure 1. Aligning PSI spaces with a 2nd level PSI

Conceived in this way, the PSI framework allows framing any design challenge and specifically a development project and through this framing, focus on the aspects that need change. These may be a new or modified product or service, with new or existing technology (P space), a change in organizations or society (I space), or a change in people capabilities and skills (S space). As stated before, identifying one or several necessary changes may lead to others due to the need for alignment.

5 CASE STUDIES OF ECONOMIC DEVELOPMENT AND PSI

In this section we take up two cases of technology-centred efforts in the developing world context, in each case in India. The first example is that of biomass cooking stove, directed at the poor who are the primary users of biomass for cooking and the second case is a solar-based rural electrification problem addressed by the Indian central government and by a local entrepreneur.

5.1 Biomass cooking stove

5.1.1 The case

Many people in India, especially in rural areas, rely on the burning of wood to cook their food every day, with implications for health and safety and pressure on wood supplies. The traditional cooking stove in India was made out of mud and bricks with an open mouth and opening for feeding the fuel. This has been used for centuries and is very smoky, leading to health problems especially for women, who are also the primary collectors of firewood as part of their daily life. 76% of rural households and about 26% of urban household use these stoves, and there are close to 260 million households in India (Hude, 2014). The very limited impact of attempts to introduce improved wood stoves in India is a simple example of dramatic failure with respect to technology and development (Khandelwhal et al., 2016). The implications of clean burning (minimal smoke), high heat efficiency biomass stoves as substitutes for traditional wood burning would be with respect to health, better efficiency stoves, and lower CO2 emissions. However, for a variety of reasons the widespread adoption has failed.

The goal of all cooking stove projects was to create a better stove that would minimize household smoke pollution. There are two primary types of stoves: natural draft and forced draft stoves. Forced draft was primarily provided electrically using batteries for energy storage. These stoves vary in terms of continuously-fed and batch-fed fuel mechanisms. Attempts to introduce these stoves have been made by different institutions, government agencies, NGOs, international agencies and corporations. The studies show that women do not use these new stoves as they have been developed to provide a one-size-fits-all model that does not take into consideration the cooking habits of daily life of particular regions. The women also did not use the new stoves because they now have to buy the fuel for them whereas formerly it only took time to gather firewood. The efficiency in cooking of the meals that are traditional to a region in terms of time to cook is also a very critical factor in their adoption. In effect, the concerns of the women are in the totality of their daily lives and their ability to maintain the stoves in the long run. The kind of shelters the users were living in and the ventilation facilities varied quite a bit across the households targeted. The cost of the new stoves, financing for the stoves, institutional support and maintenance, the supply chains and other aspects were not worked on with the communities. Besides, there are institutional barriers including subsidies for kerosene and LPG that distorted the market. All of the experimental new stoves have been based on an incomplete conception of the problem of designing the stove, viewing it as a technical task without a holistic perspective.

5.1.2 Interpreting the Bio-mass Case study with PSI

The problem of the cooking stove is a classic problem in design and development: development as ownership of a new designed artefact that makes your life better or even gives freedom from drudgery. The design did not achieve the goal. Viewed from the PSI perspective (see Figure 2), we use 2 levels to explain this case. At the 1st level we describe the daily life of the community, using the product; here the stove but in any other development project, it would be another product. Without any additional step, it is clear that in order to execute the project, there may be a change in the way the community operates. If so, the community might in time need additional skills to operate and manage the solution. It is clear that if these changes will conflict with other needs, a cascading change process will ensue. In effect, the development project needs to be framed in P' as consisting of the whole 1st level: the way members of the community use the product for their purpose and the issues they have with this (represented by the P space), those in the community involved in the operation (S space), and the rules and customs governing the operation (I space) and extending to other life functions (P space). The problem in the P' space is to change or develop all P, S, and I, in tandem and in alignment to each other. The development project had to be executed as a 2nd level PSI to take this perspective. Such setup immediately calls for enlisting professionals, experts in local culture; but even this may be insufficient as in this case because the local community members have to be part of the development team - they are the sole experts in their daily lives! In reality, the project was executed very differently. The P' space itself was conceived by engineers and scientists (S') far away from the location of use, thereby not involving members of the S space in defining the P' space and not understanding any of the issues in the I space. Members in the S' space considered the P space only in framing the P' space, a violation of the principles of 2nd level PSI described before. Quite a variety of stoves have been constructed with the same or similar S' beyond the experiment being conducted. The ignorance of the S and I spaces in framing the P' space led to considering a single solution to all contexts where in fact, each should have been modelled as a separate

1st level PSI. If the problem was modelled correctly, each context, including a variety of implementing NGOs or remote corporate or government organizations and their practices that populated the S and I spaces, would have its own 1st level PSI. This would have led to addressing such a multitude of issues with much better technological, social and institutional design. Such a model would have led to sharing knowledge between these contexts that otherwise was lacking because it had no relevance in framing the problem. A solution that only changed the P space would create misalignment between the PSI spaces and made the solution unsustainable. There was no knowledge in the S' space to change the S or I spaces; therefore, no sustained supply chains were conceived as part of the solution, no changes in the Government policies (institutional) were ever contemplated, and there were insufficient funds to even attempt to maintain and sustain the new situation. In effect, there was no thinking about the total design problem but only about unconnected fragments.

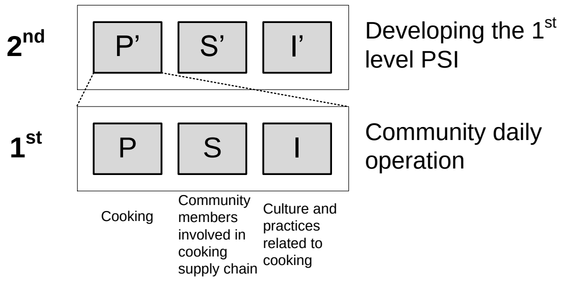

Figure 2. Modeling the cooking problem with a 2-level PSI framework

5.2 The Cases of Rural Electrification: PSI analysis of a success and a failure

5.2.1 Rural Electrification by grid extension

Another example of failure in development is the case of rural electrification in India. In its quest for modernization of rural villages, India created an ambitious program to electrify about 600 rural villages in 6 years by creating an electric grid to be supplied by large power stations (Harish et al., 2014). This program was to extend electric power distribution lines to villages and if 10 percent of the households in a village were electrified then the village was deemed to be electrified. Even though many villages were connected, the problem of supply was acute leading to the issue of intermittent services that ranged from 2 hours a day to 6 hours a day in different regions of the country. Often the power was not available when needed, in effect making the service useless to its consumers.

In this model, the approach that had been used in developed countries with centralized power generation and distribution networks was being replicated by the government. There were only half-hearted attempts at producing decentralized power. This dominant model of design persisted even though supply often could not keep up with demand and there were poor institutional structures to maintain the infrastructure leading to frequent non-functioning of the distribution systems. While this has worked in urban areas, in rural areas electrification has always been a challenge as it was addressed only technologically. It was shown in the work by Harish et al. (2014) that a combination of extension of the grid and local power generation could overcome the costs of unreliability of the grid. In this model the problem was conceived as grid-based electricity provision by the central government without any concern to the institutional needs and daily needs of the people.

5.2.2 PSI in Solar power based Rural Electrification: A success story

SELCO is a social entrepreneurship that works with solar power for lighting and electrification for the poor in the rural market in India, starting in 1995. SELCO was started as a one-man operation trying to sell solar-powered lamps in Rural South India (Hande, 2010; Mitkowski et al., 2009). The first problem that was faced by Harish Hande, the co-founder, was that people such as street vendors and the poorest were not able to buy the lamp that was 300 to 400 rupees ($4-6US). So, in order to make it easier for them, he came up with a scheme for them to pay 10 rupees a day instead and that made it possible for them to engage as they did not need to have access to cash for purchase. However, this alone was not enough – he had to also make sure the solar power systems' lamps were serviced and maintained, and to do this he picked people who were bicycle mechanics or others with some technical ability (even with minimal education) and trained them. This provided employment and a local servicing capability leading to increasing adoption. In PSI terms, see Figure 3, Hande, operating at the 2nd level PSI framed the problem in the P' by incorporating knowledge about the whole 1st level PSI; he addressed the problem of lack of skills in the S' space for the product to be sustained by creating an institution in the I' space to address that problem.

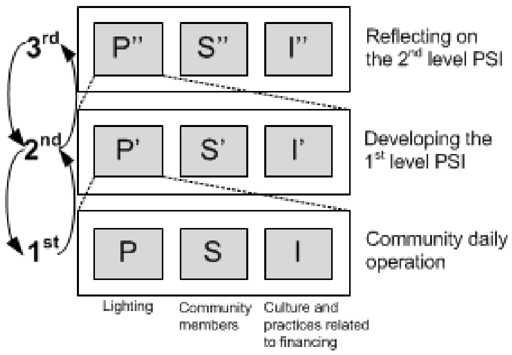

Figure 3. Modeling the SELCO case with a 2-level PSI framework

Inspired by the success of the program in its limited reach SELCO decided to scale up the operation using a franchisee model (creating a new I'). However very quickly, the scale up was not achieved and the company was at the verge of bankruptcy due to pressures from the investors. The root cause of the problem was that the franchisees, without any commitment to serve the poor, were not selling it to the poorest but to those at higher income levels where the market was weak. In PSI terms, the problem was a missing 3rd level of reflection as shown in Figure 3. Reflection looks at the lower level and tries to detect and correct misalignments. The franchisee model (I') was misaligned to the original problem definition (P'), but it could not have been detected without the 3rd level. On the verge of collapsing, this level was created.

SELCO realized (P'') that there is need for realignment of the I' to be able to address the original problem of providing the poor with lighting and electric power. SELCO also realized that using off-the-shelf components and creating a standardized model of the product was insufficient to address the varying needs of its customers. This led SELCO to reorganize itself by changing the focus of the product to customer centric products and starting its own regional sales and service centers. The regional centers were supported from the central office in terms of managing accounting, product design and finance. SELCO also created a complex financing and credit structure, identifying investors who were willing to live with lower single digit returns on investment and addressing issues of guarantees for repayment to banks with individuals and organizations who were willing to provide them. Here, SELCO changed the S' space in terms of investors, the I' space in terms of the new structure of operations, to address a new framing of the problem (in P'). Along these lines, SELCO also made arrangements to collaborate with specific NGOs that served the needs of the poor such as the women's empowerment organization SEWA. SELCO's product had to change and adapt beyond household use of lamps as the needs of the rural customers and their livelihoods and life practices were studied through the project. A modular system was created that allowed flexible use of lights as and where needed. In this entire process, the P' space for SELCO's design changed from a standardized lamp to a modular lamp, to include also financing systems and also repair and maintenance shops. For this shift, the S' space changed from just comprising Hande by himself to include the street vendors to women's groups to people in varied occupations in designing the product and the financial structure with financial experts and the banks. Subsequently, in working with rural customers, the need for repair and maintenance (skills required at S') and for new institutional structures for training people (I') were identified. In each stage Hande faced obstacles including uncooperative banks who would not give credit to many of his poor customers (I), variable acceptance of the technology (S), the need for assurance of service once bought (I) and the need for easily operated, contextually situated products (P). In dealing with each of these, the design team either had to co-opt existing institutional structures or create new ones to address the growing problem scope (P') and the social dimensions that increase with the scope and concomitantly the institutional structure.

SELCO eventually set up an innovation lab (S' and I') that was directed at new products for the poor that included solar-powered head lamps (P) for rose pickers and silk worm workers. The success of SELCO has come because the company paid attention to the PSI space in spite of the fact that as a company it grew out of necessity in a developing country with weak institutions. As we have seen in the alternative case of the cook stove, the institutions were too weak to sustain the product and no effort has been made in a systematic way as in the SELCO case (Harish et al., 2013; Hande, 2010). SELCO now is entering the cook stove market.

This and the other example in the text can also be analyzed in terms of how the problem was conceived, by whom and for whom, what were the institutional structures that existed before and what changes are needed to deal with the changed context. From a PSI perspective, the P' space as defined depends on who is involved in defining it (S' space). Mobilizing the right people and skills at the S' space would lead to considering in P' also all issues relevant to the S and I spaces. Once P' is framed in such a holistic manner, each solution will co-evolve the P, S, and I spaces in tandem and aligned. In the case of the cook stove, a first step would be to ask the women about their daily life and practices, a second step to examine the supply chain as most of these new stoves use processed biomass or prefabricated pellets. The need for women to earn money to substitute for their time in collecting free firewood means they will have to have a stake in the production fuel and even the supply (possibly local) of the stoves. For example, in India, women typically spend on average 347 hours a year, collecting firewood (Practical Action, 2015). The problem is not simply the stove; the problem is a complex systems design that includes technology and institutions that needed to be recognized. PSI provides a means to ask the right questions whether in development or design. There are other successful cases that have worked as in the case of SELCO. In those cases, the organizations evolved to address the problem in a holistic manner that involved expanding social space, problem space and institutional space (Brilliant and Brilliant 2007). In all development problems, the original issue is not known and it requires understanding and adapting to the context that includes institutional design.

6 DISCUSSION AND CONCLUSIONS

In this paper, we have expanded the relationship between economic development and engineering. We have explored this relationship by characterizing current models of economics-centered development and the role engineering and technology has played in development. We use the PSI framework to extend the scope of engineering design to a holistic view that includes the actors and the institutional structures that are integral to engineering design in context. We use the framework to present two case studies of technology design and introduction in the Indian context to explain failure of the first and success of the second. We concur with Bhalla's (1979) call for 'appropriate technology' - that "application of technology developed elsewhere will not lead to the best results and may even be counter-productive". Our major contribution is the use of an expanded theory of design in the PSI framework to account for failures in engineering technology for developing world context and to provide a framework for the design of that appropriate technology. Viewed with this framework, it is clear which issues need to be incorporated in development projects including their sustainability. It is also clear why previous approaches fail because they do not partner with the necessary stakeholders to create S' that could frame the problem P' with all its richness. Very often, they simply use P'=P. The approach we presented is also of relevance to contemporary societal problems. It is our contention that engineering approaches when extended provide us with the ability to use them in understanding and delivering the needs of the people we serve technically, socially and institutionally.

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