ICT4D Design Patterns for Common Language in ICT Ecosystems

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Qualifications

BA in Political Science, Keio University, Japan in 2002. PhD in Media and Governance, Keio University Graduate School of Media and Governance in 2007. He has been engaged in research on both design theories in interdisciplinary design and practices based on them with a background of sociology, philosophy, psychology and computer science. His work has been entered into a number of challenging competitions such as SIGGRAPH Emerging Technologies (2003, 2005), Japan Media Art Festival (2004, 2007), Asia Digital Art Award (2005, 2008), FILE (2007, 2008), Laval Virtual (2006, 2008) and U-35 Creators Japan (2013).

In addition to academic activities, he has contributed to society based on his academic achievements. While studying at the Graduate School, he co-founded UTUTU Co., Ltd., and in 2009 he co-founded Sikake, both of which are organisations who design communication media to deliver more fun in our daily lives with innovative technologies. In 2013, he was appointed as CCO (Chief Creative and Communication Officer) of Navigator Platform Inc. which organises a media for personal investors.

Recently, he has been especially interested in a design framework to achieve Design Driven Innovation which means a radical change of meaning about a product, a BOP (Bottom of the Pyramid) design framework to achieve Vernacular Innovation which focuses on local and natural elements in the field, and a Pattern Language for the developing world. His research concept is to develop design tools and methods using models from the designers' viewpoints.

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Abstract

An ICT ecosystem encompasses the policies, strategies, processes, information, technologies, applications and stakeholders that together make up a technology environment for a country, government or an enterprise, and includes diverse individuals. This environment needs a common language to discuss the technologies. This research uses the concept of Pattern Language by architect Christopher Alexander as a common language, and aims to propose an original format for ICT4D Design Patterns. Compared with the existing design pattern in software engineering and HCI (Human Computer Interaction), ICT4D Design Pattern focuses on contexts. This is because the contexts in which simple but wicked problems arise are quite complicated in the BOP, and designers cannot find problems or offer solutions ahead of the contexts. ICT4D Design Pattern is described with a format of Name, Area, Context, Problem, Example, Category, and Impact, and this paper indicates a design pattern as a sample. The next step will increase the number of design patterns, reveal the relationship among the elements which consist of contexts, and develop a Pattern Language.

Keywords

BOP, ITCT, design pattern, pattern language, format.

1. Background

An ICT ecosystem has two features. The first feature is that it encompasses the policies, strategies, processes, information, technologies, applications and stakeholders that together make up a technology environment for a country, government or an enterprise. The second feature is that it includes diverse individuals who create, buy, sell, regulate, manage and use technology [1]. This environment needs a common language to discuss the technologies. Referring to the history of design, we can find such a kind of language. There is Pattern Language in architecture. Pattern Language was originally developed by architect Christopher Alexander [2]. This is a collection of design patterns used as a common language that forms a bridge between architects and users.

A design pattern is a design method with the purpose of offering a solution to a specific problem regarding design in a context. The pattern language of Alexander has two features: “format” and “hierarchy”. The format is a style to describe a design pattern that consists of basic components such as problem, context, and solution. This style aims to provide a proven solution to a problem of design which is easily understood by the end user as well as by the architect. Hierarchy refers to the relationship between patterns. These relationships have two characteristics: deconstruction from the abstract and large-scale to the concrete and small scale; a close connection between each pattern. When design patterns have a structure of hierarchy, they can be called a Pattern Language.

What format do we need when we develop ICT4D Design Pattern as a common language? First, we want to clarify that most of the problems in the developing countries are simple, but wicked. For example, some people cannot receive adequate education, and some villages have no irrigation. However, the contexts in which these problems have arisen are complicated. To solve these simple and wicked problems, designers have to conduct a huge number of surveys. What religions do they believe in in the field? And how much influence do these hold? Which countries conquered the country, and how has the language system adapted to the relationship between these countries? What prevents local people having a basic infrastructure? Designers have to answer each question carefully. Behind a phenomenon, several elements

based on a variety of contexts mingle. Thus, this structure generates a wicked problem which seems to be simple.

Existing design patterns, especially in software and interaction design, are defined as patterns based on the unique relationship between problem and solution. Some elements within the original design patterns are lost, such as detail contexts in the format and the hierarchy which considers the relationships between patterns. On the other hand, ICT4D Design Pattern, which the author proposes in this paper, emphasises contexts. This is because the contexts in which simple but wicked problems arise are quite complicated. If designers check only a problem and its solution without any of the contexts, this definitely causes some trouble when the patterns are implemented. Also, this research aims to reveal the relationships between several elements which are composed of contexts that seem to be complex. This will enable us to reveal the relationships between patterns, and the development of a pattern language for the developing world with a hierarchy.

The scope of this paper defines a format for ICT4D Design Pattern. Based on the format, the author describes a sample of a design pattern. After developing the appropriate format for ITCD and a sample using the format, we can create design patterns using several successful case studies related to ICT4D in the world. With these design patterns, the author wants to discuss the following points:

1) What are the features which ICT4D Design Pattern should have?
2) How appropriate are the formats proposed in this paper?
3) How well does ICT4D Design Pattern work as a common language in an ICT Ecosystem?

2. Related Research

2.1 Design Pattern

The Pattern Language by Alexander has been applied in the realm of software engineering since the 1980s. Design Patterns by Gamma is a catalogue that records some important parts which repeatedly appeared when designing object-orientated software as design patterns [3]. This is the first book for pattern language on software engineering, and this means that the introduction of pattern language to software

engineering preceded HCI. But, some researchers of HCI patterns pointed out that this book has several defects. For example, the patterns in the book are for developers and engineers and it does not focus on end-users [4]. Nor does it have any structural approaches [5], and also does not have a general format as a pattern language [6].

Design pattern and pattern language on HCI are divided into three phases. First, the introductory phase started a CHI workshop in 1997 [7]. The author regards it as the start of this phase because it was the first to propose the concept of design pattern to HCI. Next, the expansive phase continued from around 2001, with the publication of *A pattern approach to interaction design* by Jan O. Borchers [8] to around 2003. The author defines this period as the extended phase because this was the period when papers about design patterns on HCI were published most frequently. The main topics are the definition of design pattern on HCI, the purpose and format of the design pattern, and development of each design pattern. Finally, the penetrating phase started from 2003 when a paper about application of design patterns to ubiquitous computing by Landay was published [9]. The author calls this the penetrating phase because the realm of design pattern was widespread from basic areas such as UI, web and HCI to a variety of other areas.
The trend in the last ten years has been a decrease in publication of the number of papers on HCI design patterns. However, discussion about design pattern in games and education has actively continued. In 2012, an international workshop about game design pattern, GDP, was held, and several patterns were proposed to design some elements and functions in games. As regards design patterns in education, Breuer et al. proposed four design patterns for mobile learning [10]. Also, they developed four interaction design patterns which can be used to design a classroom [11].

2.2 BOP Product Design

Designers in developed countries should be aware of the fact that the population in developed countries constitutes less than 10% of the world's population, and they are designing products for this 10% [12]. Another four billion people belong to the socio-economic group called the bottom of the pyramid (BOP). Prahalad and Hart [14] defined BOP as the people who live on less than $2 a day. The people in the BOP group cannot afford to buy most of the basic products that are familiar to us because

the cost of the products and the infrastructure that the products rely on are not available to them [13]. Regarding this situation, following the Millennium Development Goals of the United Nations [15], companies and research institutes in developed countries have been expanding projects to solve a variety of social issues for BOP. Recently, Microsoft India, MIT D-lab, Stanford d.school, TU Delft, and IDEO.org have been leading the way by developing a large number of applications, products and services for BOP.

Research in the realm of BOP is mainly survey, case study, and design framework. Papers concerning surveys aim to investigate specific areas, or the present situation among several areas. Papers about case studies dominate, and aim to conduct fieldwork in specific areas, to design some products, applications and services based on the results of fieldwork, and to evaluate the products. Finally, papers about design framework on BOP are composed of design processes and some tools which can be used in each process. The typical frameworks are HCD Toolkit [16], D4S [17], BOP Protocol 2.0 [18], and Market Creation Toolbox [19]. However, there is no research on design patterns on BOP. There are already a number of case studies which give enough information to develop design patterns. By developing a design pattern on BOP, many projects can refer to it and will try to develop some products to solve simple and wicked problems in a variety of areas and countries. This enables them to solve the problem appropriately and efficiently.

3. A Format of ICT4D Design Pattern

3.1 Concept

The format of ICT4D Design Pattern emphasises context rather than problems compared with the existing HCI design patterns because BOP projects emphasise phenomenon, and BOP product design starts from the observation of phenomena. First, designers conduct fieldwork and observe phenomena in each field in detail. As a result of this process, they focus on the target which should be designed. We can observe many phenomena. Some are related to natural phenomena, such as the fact that some people can get clean water and that geography is complicated. Some are related to socio-cultural phenomena such as a local language that has several words for “horse”, or the fact that adult males in a community do not work during the

daytime. After focusing on the target, approaches to the issue to be tackled can be derived from the phenomenon. For example, when we can observe machine tools which were given by developed countries via ODA at University and so on, we can expect that the community has some engineers who can use them or some candidate engineers who will be able to use them. Designers can develop products based on these technologies and environments.

An emphasis on phenomena only cannot deny the possibility that the designer will fall into dogma. This refers to the phenomenon whereby designers construct structures between problems and solutions based only on the designer's interests. For example, most of the designers in developed countries tend to focus on the phenomenon that smoke from burning firewood fills the house when they observe very primitive cooking stoves which are used in most of the developing world. They will easily develop a structure that offers fuel without smoke as the solution, which will make the people working in the cooking space more healthy. But this structure is only based on the designer's interest, and cannot take the environment or customs of the local people into account. The local people protect themselves from harmful insects using this smoke.

To overcome this problem, ICT4D Design Pattern adopts the concept of "interest correlativity" as a theoretical background. Interest correlativity is the principle of phenomenology whereby existence, meaning, or value is not absolute, and is relatively identified according to the physical situation, desire, purpose, or interest in the subject. For example, we rarely notice a puddle in the street, but when the subject is dying of thirst, this puddle constitutes valuable drinking water, and appears as an existence with such a value. Using the example of the cooking stove again, designers cannot develop an appropriate hypothesis as long as designers do not take into account the situation of housing with many holes and the local people's desire to use smoke for protection from insects. In addition to designers' interests and purpose, to understand the local people's interests and purpose enables designers to develop appropriate products corresponding to the situation.

3.2 The Format

The format of ICT4D Design Pattern in this paper is composed of the following seven elements.

Name

"Name" describes the name of the design pattern.

Area

"Area" describes country and region where the contexts arise. The reason for putting Area at the beginning of the format is that the following elements depend on each area.

Context

"Context" describes the situation around the design pattern. The situation means the elements which are extracted as specific parts from phenomenon which appeared to the designers during a survey before fieldwork and during fieldwork. Based on the PESTLE Model[1], Political, Economic, Social, Technological, Legal and Environmental elements should be described. In addition to these, people's interest as qualitative elements must be described.

"Political" (P) describes the elements to explain the influence which a government may have over the environment where you conduct your project such as a business cycle, economy or a certain industry. For example, the political elements include tax policies, fiscal policy, trade tariffs and so on.

"Economic" (E) describes the economic elements towards the world-wide economic trend and long-term effects. For example, this element includes inflation rates, interest rates, foreign exchange rates, economic growth patterns, etc.

"Social" (S) describes the socio-cultural elements such as cultural trends, gauge determinants, demographics, population analytic or impact of the mix among different cultures.

"Technological" (T) describes the technological trend around the environment where you conduct your project. This covers the frequency of innovation and the extent to which they directly or indirectly influence the business which you start.

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[1] http://pestleanalysis.com/

“Legal” (L) describes laws or policies which directly influence the project which you conduct. They will be social laws related to medical services, public welfare, sanitation and labour or regulatory laws.
“Environmental” (E) describes the ecological and environmental aspects which your project has. Not only do you have to survey the ecology and environment in depth but you also have to consider the influences which the environment directly or indirectly has on the project.
In addition to these, people’s “Interest” as qualitative elements must be described.

Problem

“Problem” describes an issue which should be solved based on the context. Even if the contexts are the same, we have the possibility of there being many different problems to be solved.

Example

“Example” describes a product, service or application which is developed for the problem. This element should include photos and drawings. Also, even if the problem is the same, we have the possibility of there being many different examples.

Category

“Category” describes the categories where each design pattern should be included. We adopts the same five targets as ASME (American Society of Mechanical Engineers): Health, Energy, Transportation, Food/Water, and Housing. In addition to these, we adds three elements: Use, Learn, and Generate Income; these are related to types of user engagement. Thus, Category should be described with a matrix with targets and the type of engagements (Table1).

Impact

“Impact” describes sustainable influence on three factors: Society, Economy and Environment. Social impact describes what kinds of sustainable influences can be produced when a product is installed in a community, area, or country. Economic impact describes what kinds of holistic and sustainable influences can be created when a product is installed. Finally, Environmental impact describes what kinds of

sustainable influences can be reflected when a product is widespread in the whole of the developing world.

4. A Sample of Design Pattern

Table 2 is a sample of design patterns for the developing world which is described based on the format in Section 3.

5. Discussion

Section 5 discusses 3 points which were mentioned in Section 1 using the format of the design pattern and its sample.

1) What are the features which ICT4D Design Pattern should have?
2) How appropriate is the format proposed in this paper?
3) How well does ICT4D Design Pattern work as a common language in an ICT Ecosystem?

First, the feature which ICT4D Design Pattern should have is related to the element T (Technological) in the Context of the format. For example, the prevalence rate of the network such as the internet, cellular network and the diffusion rate of the communication device such as computers, smart phones and mobile phones are important premises to design solution. We have to reflect the results of the surveys on these points.

Next, in order to discuss the appropriateness of the format which the author proposed as ICT4D Design Pattern, we have to discuss it according to the element T (Technological). The author suggests adding the new element “ICT” into the Context. The element T is the aspect which describes the technological trend around the environment where your project is conducted as has already been mentioned, and does not focus on ICT. But, ICT should be included as an independent element as it is indispensable in confirming the prevalence rate of ICT for the ICT4D Design Pattern.

Finally, about the point how well ICT4D Design Pattern works as a common language in an ICT Ecosystem, the author developed the format by considering the feature

which the original design pattern had, which means easy for the end users. The design patterns in software engineering, UI and interaction design have been criticised because they don't consider the usage by the end users. Based on this critique, ICT4D Design Pattern pursues an easy-for-the-end-users method. For example, the design pattern adopts the element Interest in the Context, and describes environmental, social and economic Impact for the end users to understand the effectiveness of installing the design pattern.

6. Future Development

This research will increase the ICT4D Design Patterns based on a variety of case studies. They are related to the products and research conducted by universities, research institutes, companies, NPOs, and so on. The author will describe design patterns using them with the format set out in this paper. Also, the author will develop an online database where every user can check the design patterns. This service will extract some tags from the texts on seven elements in the Context as Context Tag.

Using the database, this research will conduct three analyses. First, the author will visualise the areas where the existing BOP products, services or applications have been developed. This research will analyse some common elements in the area where many products have been implemented. Second, the author will visualise the categories in which the existing BOP products, services or applications have been developed. Also, this research will extract some common elements in the area where many products have been implemented. Finally, this research will analyse the relationships between Context Tags. By visualising the relationships between tags and removing limitations such as areas and categories, the author will acquire insights into the elements which can be connected strongly or weakly.

Acknowledgement

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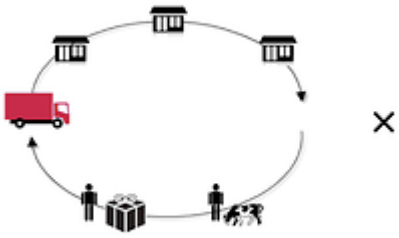
Table(s)

Table1. The Category Matrix of the Design Pattern

	Use	Learn	Generate Income
Health			
Energy			
Transportation			
Food/Water			
Housing			

Table2. A Sample of Design Pattern

Name		To decrease the logistic cost from rural areas to the capital.
Area		East Timor
Context	Political	Two independence wars from Portugal and Indonesia. Independence after the interim era by the U.N from 1999 to 2002. Depend on public sector due to too much support after independence.
	Economic	80% of the areas in the country have no electricity owing to two independence wars. Industrial stagnation due to dependence on oil industry which constitutes more than 20% of GDP. 90% of the people are engaged in agriculture, but they only amount to about 40% of the GDP. Economy only concentrates on Dili, the capital of East Timor. A charter service from rural areas to the city costs from 300 to 500 USD.
	Social	The languages are complicated because education and public administration are in Portuguese, work with an NGO or UN is in English, and daily lives are in the local language. 99% people are Christian (Roman Catholic). Less entertainment.
	Technological	There are some machine tools given by NGOs. They have skills to mould ceramic.

		There are some carpenters in the villages who have woodcraft skills. Cellular network exists in the rural areas.
	Legal	The language of law is complicated, and every law is written in four languages: English, Portuguese, Indonesian, and Tetung.
	Environmental	High temperature and humidity. During rainy season, it continues raining so heavily that they cannot work in agriculture. We can see many bamboo, banana and coconut in a variety of areas. Casaba and coffee are produced in large quantities. The landscape is too complicated to develop logistics.
	Interest	Family-centred culture since Portuguese colonial times. The people emphasise their traditions, customs, and ancestral legacies. If the people have money, they and their children could have better education. The local people love communication with cellular phones such as SMS and phone call.
Problem		The logistic costs from the rural areas to the city are expensive, and the people in the rural areas cannot transport their products to the city. This is one of the reasons why industry in the rural areas has not been developed.
Example		There are some trucks to transport some products from the capital to kiosks in each village. They have the products on the way to each village, and return empty to the city. This can be used as a resource. The farm producers can send an order to pick up their products to a logistic company via SMS. The company can get the picking-up information from each farm producer via an Android application “tranSMS”. After the company delivers their luggage to the kiosks, it will retrieve the products from each farmer and transport them to the city.  × 

<table>
<tr><td colspan="2">Category</td><td>
<table>
<tr><td></td><td>Use</td><td>Learn</td><td>Generate Income</td></tr>
<tr><td>Health</td><td></td><td></td><td></td></tr>
<tr><td>Energy</td><td></td><td></td><td></td></tr>
<tr><td>Transportation</td><td></td><td></td><td>tranSMS</td></tr>
<tr><td>Food/Water</td><td></td><td></td><td></td></tr>
<tr><td>Housing</td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td rowspan="3">Impact</td><td>Environmental</td><td>The logistic companies only give environmental load and spoil resources because they don’t carry anything to the city. On the other hand, they can make use of this resource by using this application.
The environmental impact increases if the number of the trucks from the city to the rural areas increases to more than the present number.</td></tr>
<tr><td>Social</td><td>The rural society and industry will be enriched because the rural products can be transported to the city. They originally cannot be transported there.
If the city expects too much production, there is a possibility that the labour environment in the rural areas will be distorted.
There is another possibility that the production system in the rural areas will be changed due to the needs of the city.</td></tr>
<tr><td>Economic</td><td>The farmers can get a new income source because they can sell their products in the city.
The logistics company can get a new income source because they can make use of the resource which they have been unable to use on the return journey to the city.
The retailers can get a new income source because they can handle new products from the rural areas.</td></tr>
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