DESIGN FOR RESOURCE-LIMITED SOCIETIES: INFORMATIONAL BEHAVIOUR OF DESIGNERS

Jagtap, Santosh (1); Larsson, Andreas (1); Warell, Anders (2)
1: Blekinge Institute of Technology, Sweden; 2: Lund University, Sweden

Abstract

There is a sharp contrast between High Resource Settings (HRSs), commonly seen in developed countries and Low Resource Settings (LRSs), typically found in the marginalised sections of societies around the world. Product design for LRSs is crucial to satisfy unmet or under-served needs of the people living in LRSs. Supporting designers to develop successful products for LRSs demands developing an in-depth understanding of their design process, including their informational behaviour. In this research, using think aloud protocol analysis, we compared the designers' informational behaviour in designing products for LRSs and HRSs, where HRSs is considered a baseline. The findings indicate that designing products for LRSs is more information intensive, and that it influences the informational activities of designers, thus indicating potential impact of a resource-setting on the way designers deal with information.

Keywords: Design process, Human behaviour in design, Design cognition, Poverty and Base of the Pyramid, Resource-limited societies

Contact:
Dr. Santosh Jagtap
Blekinge Institute of Technology
Product Development Research Lab
Sweden
santosh.jagtap@bth.se

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1 INTRODUCTION

The world income pyramid is typically divided into three segments - top, middle, and bottom (Prahalad and Hart, 2002). The *top segment* is variously known as 'Top of the Pyramid', 'developed world', 'industrialised world' or *'High Resource Settings' (HRSs)*; whereas the *bottom segment* is commonly referred to as 'Base of the Pyramid', 'marginalised sections of the society' or *'Low Resource Settings' (LRSs)*. In the present paper, we use the terms HRSs and LRSs to refer to top and base of the world income pyramid. The people in LRSs routinely face the complex and entrenched problem of poverty. While two-fifths of the world population lives with meagre income of less than 2 dollars a day, a fifth lives in extreme poverty with income below 1.25 dollars per day (Karnani, 2011). Although poverty is decreasing, it remains a persistent and widespread problem with institutional, individual and structural causes, effects and potential solutions. Whilst Mahatma Gandhi called poverty as 'the worst form of violence', Amartya Sen explains it as a lack of freedom (Sen, 1999). Others again define it in terms of ill-health, high mortality rates, and hunger or as a monetary issue (e.g. Jönsson et al. 2012).

Any poverty reduction approach consists of the design, development and implementation of an intervention with specific targets to achieve, e.g. to provide access to affordable and clean energy alternatives or to stop spread of certain diseases. These interventions may take a variety of forms such as products, services or product service systems, and may be developed by governments, civil society (e.g. NGOs) or businesses, either individually or collaboratively (e.g. Prahalad, 2005; Nakata, 2012; London and Hart, 2010; Karnani, 2011; Aranda-Jan et al. 2016). Design of products (e.g. smoke-less stoves, medical devices, shelters, etc.) for LRSs is imperative to satisfy the unmet or under-served needs of the people living in poverty. Some universities are offering courses and/or projects related to product design for LRSs.

Because poverty and LRSs are multidimensional issues, they are subjects of research in many disciplines such as geography, economics, anthropology, sociology, medicine, and political science. Based on numerous perspectives and domain-specific expertise, researchers generate both descriptive and prescriptive knowledge aimed at understanding and alleviating poverty (Prahalad 2005; London and Hart, 2010; Karnani 2011). While design research has largely been carried out in the context of developed countries or relatively affluent markets (Jagtap and Larsson, 2013; Jagtap et al., 2013), there is little empirical examination of the phenomena of product design for LRSs, limiting our ability to develop methods and tools to support practice and education of product design for LRSs. It is crucial to develop an understanding of design for LRSs.

Designing products is an information intensive activity, with some authors describing it as the process of converting information in one form into another form, while accessing and using information on a variety of issues and topics (e.g. Jagtap and Johnson, 2010; Hubka and Eder, 2012). The present study aims at exploring the differences between the designers' informational behaviour in designing products for LRSs and HRSs, where designing for HRSs is considered a baseline. The differences between their informational behaviour become clear due to the sharp contrast between the LRSs and HRSs. To address the research aim, we used the experimental technique of think aloud protocol analysis. In a laboratory setting, four designers solved a design problem for LRSs and four other designers solved the same problem for HRSs.

2 DESIGN FOR LOW RESOURCE SETTINGS

2.1 Low Resource Settings

The World Bank project '*Voices of the Poor'*, examining how poverty, well-being and ill-being were perceived by 60,000 informants in 23 countries, identified numerous issues ranging from individual experiences of hunger, ill-health, and unemployment to more institutional and structural problems of state corruption, climate vulnerability, and gender inequality (Narayan et al. 2000). People living in poverty often cannot save or invest, or change their living conditions and livelihood opportunities, due to their weak access to financial and other resources and their huge need for immediate consumption (Jerneck 2013; Karelis 2007). They often face difficulties to satisfy basic needs such as food, shelter, and clothing, and lack access to basic services such as education, public health, sanitation, safe drinking water, infrastructure, and security (Karnani 2011).

As a multidimensional issue, poverty is studied in many disciplines, and scholars aim to understand the nature of poverty and prescribe interventions to alleviate it. These interventions may come in many forms such as smokeless cookstoves (Jerneck and Olsson 2013), medical devices (Aranda-Jan et al. 2014), financial services such as conditional cash transfers or microcredit (De Mel et al. 2012), vaccination programs (e.g. Marmot et al. 2008), or state policy to support agriculture and water distribution (e.g. Angelin et al., 2014; Buse et al., 2009). Design of products for the LRSs is important to satisfy unmet and under-served needs of the people living in poverty. Product design for LRSs is undertaken by governments as their responsibility to provide public services, by NGOs as a social service or charity, or by companies as their continual task of exploring new markets (e.g. Karnani, 2011, Prahalad, 2005).

A product design project generally aims at fulfilling some user needs and technical requirements, while addressing constraints that are specific to the target market. The sharp contrast between the constraints in LRSs and HRSs, together with the socio-cultural differences between them, mean that designing products for these markets ought to consider constraints and other aspects specific to them. Designing products for LRSs thus requires addressing constraints that are specific to LRSs. Despite differences between LRSs in different countries and regions, the constraints in these settings are commonly categorised into five types: difficulties in gaining *market information*, under- or un-developed *regulatory frameworks*, inadequate *physical infrastructure* (e.g. roads, electricity, water and sanitation, hospitals, etc.), poor *knowledge and skills*, and weak *access to financial services* (UNDP, 2008; Jagtap et al., 2013).

2.2 Design process and information

Many design process models, both descriptive and prescriptive, have been proposed by many authors (e.g. Cross, 1994; Pahl and Beitz, 1996). Although these models differ in their diagrammatic representation, detailing and terminology used to describe various tasks in the design process, they share many common characteristics, e.g. progression from abstract to concrete, presence of iterations, inclusion of decision and evaluation points, etc. (McMahon, 2012). Key ingredients of a design process are *requirements* (i.e. problems), *solutions*, *information*, and *strategy* (i.e. plan of action to progress through the design process) (Chakrabarti et al., 2004). Several studies have found co-evolution of requirements and solutions, with some studies classifying requirements into *solution-specific requirements*, which are specific to a solution, and *solution-neutral requirements*, which are broad and do not belong to a specific solution (e.g. Nidamarthi, 1999; Chakrabarti et al., 2004; Fricke, 1999).

Designing products is an information intensive activity, requiring designers to access and use a variety of information during the process (e.g. King et al., 1997; McAlpine et al. 2006; Robinson, 2010). Some authors have even described product design as the process of converting information one form (e.g. needs and requirements) into another form (e.g. final specifications of the product) (Hubka and Eder, 2012). Some empirical studies in industry suggest that, on average, designers spend about a quarter of their day in acquiring and providing information (e.g. Marsh, 1997). Studies investigating designers' requirements of a specific type of information, for example, in-service information, have also been undertaken in companies (e.g. Jagtap et al., 2006).

The focus of most of the existing studies, examining informational behaviour of designers, is on variant design tasks, with the intention of supporting designers in capturing, storing and accessing information from previous projects (e.g. Bracewell et al., 2009). These studies are typically carried out in engineering industry, e.g. aerospace industry, using empirical research methods such as interviews, questionnaires, observations, etc. to report descriptive accounts of designers' informational behaviour upon which prescriptive methods and tools are proposed, developed and evaluated. In addition to such descriptive, empirical studies in industry, studies have also been undertaken in laboratory settings, commonly using the method of think aloud protocol analysis (e.g. Kuffner and Ullman, 1991; Eris, 2002). While there are several studies investigating informational behaviour of designers, there is little or no knowledge about how a resource-setting (e.g. LRSs vs HRSs) affects informational behaviour of designers. Knowledge on the influence of a resource-setting on the informational behaviour of designers is not only important for establishing direction for further research in information management in design, but also for developing appropriate methods and tools to support design practice in a variety of market contexts, including LRSs.

3 RESEARCH METHODOLOGY

While our previous study presents the details of the research method (Jagtap et al., 2014), for easy reference we briefly present the method employed in this research, namely the method of think aloud protocol analysis. There were two sessions in this experimental method – HRSs and LRSs sessions. In each of these sessions, four designers *individually* participated; thus, in total, eight designers participated in the experiments. All these designers were Masters students in 'Industrial Design' or 'Product Design', and they solved the same design problem - designers in the LRSs sessions solved it for LRSs and those in HRSs sessions solved it for HRSs. Prior to experiments, we ensured that LRSs designers and HRSs designers had prior experience of working on university-based design projects for LRSs and HRSs, respectively. Excepting this difference, the designers in LRSs and HRSs sessions are fairly similar. The degree of unfamiliarity with HRSs and LRSs might be different in the two sessions. These differences are discussed further in Section 5. The pragmatism in the experimental arrangement allowed gaining important findings, discussed further in Section 5.

A highly contagious and deadly disease called 'anthrax-d5' is spreading across (abc). This disease is transmitted only through contaminated food and water. A person infected with this disease needs to be hospitalized in order to save his/her life. The spread of this disease is such that the existing healthcare infrastructure (i.e. available number of hospitals) is inadequate to hospitalize and treat the large number of infected people. There is an urgent need to erect a number of temporary shelters that can be used as hospitals. For (xyz), where the 'anthrax-d5' is spreading at an enormous rate, design such a temporary shelter that can be used to hospitalize 5 infected people (per shelter). Each shelter also needs to accommodate basic healthcare facilities and healthcare staff consisting of 1 nurse. The time to install this shelter must be less than 2 hours. The shelter also needs to withstand different types of weather conditions.

Figure 1 Design problem used in LRSs and HRSs sessions

Table 1 Coding scheme

Category		Description (example)
Requirement		Designer deals with a requirement ("That needs to include…", "I am assuming this should be…")
Req. type	Solution-specific (SRs)	A requirement that is specific to any of the designer' solutions (The designer, in relation to a specific solution, dealt with the following requirement, "The outside of it should be of leak-proof material to protect from rain.")
	Solution-neutral (NRs)	A requirement that is not specific to any of the designer' solutions ("The solution needs to be as cost-efficient as possible.")
Solution		Designer deals with a solution. ("Let's put cloth on inside…", "So, this is efficient to…")
Information		Designer deals with information. ("Developed countries have…", "This is actually not accurate information of…")
Informational activity	Access	Designer accesses/collects information ("Developed countries have such facilities.")
	Ask	Designer asks the researcher for information ("Does anthrax spread from person to person?")
	Evaluate	Designer evaluates or analyses information ("This is actually not accurate information of this kind of inflatable material.")
	Repeat	Designer repeats or remembers information (The designer remembered the information, "The disease is transmitted through contaminated food and water.")
	Assume	Designer assumes information ("Let me assume that these people can move on their own.")
	Interpret	Designer expresses information in a different from ("So, this also means the disease is going to kill people.")
Strategy		A plan of action for proceeding through the design process ("I will start by just taking some notes about what this task is.")

We formulated the design problem taking into account a number of criteria, including its suitability for both LRSs and HRSs. The formulated design problem is presented in Figure 1. In this problem, in the case of the LRSs sessions, *(abc)* was replaced by 'a cluster of BOP communities in a developing country'

and *(xyz)* by 'the cluster of LRSs communities'. In the HRSs sessions, *(abc)* was replaced by 'a city in a developed country' and *(xyz)* by 'the city in the developed country'. As an information source, a researcher was present in all the eight experiments. The designers were allowed to ask questions to the researcher.

The transcribed audio recordings were segmented, using previous guidelines of Ericsson and Simon (1993), with each segment representing a single thought, expression or idea. We borrowed the coding scheme developed by Chakrabarti et al. (2004), consisting of four categories - *'requirement'*, *'solution'*, *'information'*, and *'strategy'* (see Table 1). For the segments corresponding to the 'requirement' category, we coded the type of requirement (i.e. solution-specific or solution-neutral). For the segments classified under the 'information' category, we coded the informational activity, e.g. access, ask, evaluate, repeat, assume, interpret. The reliability of the coding process was measured by calculating percentage agreement between two coders, who coded two out of the eight protocols (i.e. two transcripts). The average inter-coder reliability was above 85%.

4 FINDINGS

While this section presents the findings, they are discussed further in Section 5.

4.1 Informational activities

As compared to the HRSs sessions, LRSs sessions were more information intensive, see Figure 2. Figure 3 presents the average number of segments and average percentage of segments for informational activities in the LRSs and HRSs sessions. The average percentage of segments in this figure is derived from the average percentage of segments of each designer under corresponding activity. In comparison with the HRSs sessions, the occurrence percentages of segments in the informational activities - 'access' (55.7% and 22.9%), 'ask' (20.4% and 14.6%), and 'repeat' (7.7% and 5.5%) - are higher in the LRSs sessions. In contrast, the designers in the HRSs sessions assumed more information than those in the LRSs sessions (39.8% and 7.1%). Evaluation of information was greater in HRSs sessions than in the LRSs sessions (19.1% and 13%).

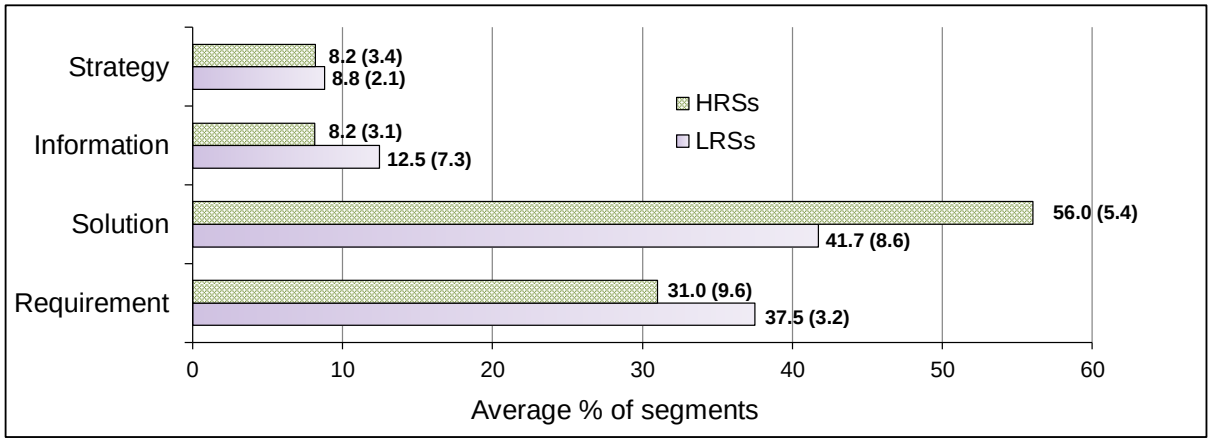

Figure 2 Average percentage of segments for major categories (standard deviation values are presented in brackets)

The LRSs designers assumed less information and asked for more information (7.1% and 20.4%), indicating their higher preference for information asking than assuming. This finding also suggests that the LRSs designers were not confident in assuming information. In contrast, HRSs designers preferred to assume information over asking for it (39.8% and 14.6%), indicating their higher confidence in assuming information.

	LRSs				HRSs			
Activity	Ave. Seg.	Ave. Seg. SD	Average %	Ave. % SD	Ave. Seg.	Ave. Seg. SD	Average %	Ave. % SD
Access	11.8	4.6	55.7	28.1	4.0	2.2	22.9	7.0
Ask	9.0	12.9	20.4	14.4	3.0	3.2	14.6	13.7
Evaluate	4.3	4.6	13.0	2.2	2.8	2.2	19.1	17.1
Repeat	4.0	6.7	7.7	9.6	1.0	0.8	5.5	4.2
Assume	3.0	3.6	7.1	8.9	6.3	3.5	39.8	30.2
Interpret	0.0	0.0	0.0	0.0	0.8	1.0	4.4	5.0

Figure 3 informational activities (Ave. Seg. - average number of segments; SD - standard deviation)

4.2 Distribution of information

Figure 4 and 5 presents the distribution of the category 'information' along the timeline. Figure 4 shows this distribution for each designer in the LRSs and HRSs sessions. A coloured bar on the timeline shows that the designer spent time dealing with information. For each designer, the timeline was divided into four equal quarters - Q1, Q2, Q3, and Q4. In each of these quarters, we counted the number of segments for the category 'information'.

In the case of LRSs and HRSs sessions, Figure 5 presents average percentage of segments for information in each quarter. This average percentage is derived from the average percentage of segments of each designer under the information category.

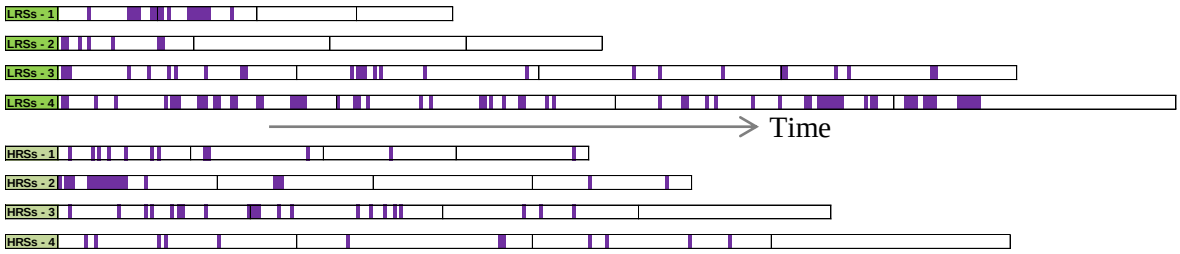

Figure 4 Distribution of information category for each of the designers in LRSs and HRSs sessions

	Q1		Q2		Q3		Q4	
	Average %	Ave. % SD	Average %	Ave. % SD	Average %	Ave. % SD	Average %	Ave. % SD
LRSs	51.7	32.4	27.6	25.5	9.8	13.3	10.8	12.5
HRSs	54.5	17.2	27.3	13.3	13.8	14.2	4.4	5.0

Figure 5 Distribution of informational activities – average percentage of segments along the timeline (Ave. - average; SD - standard deviation)

The HRSs designers dealt with information primarily in the beginning of the process, i.e. in Q1 (see Figure 5). As compared to them, the LRSs designers handled information throughout the process, and were engaged more with information in the later phases of the process – Q4 (10.8% and 4.4%). This finding suggests that as compared to HRSs sessions, the LRSs sessions were more information intensive throughout the entire process.

4.3 Transitional behaviour and information

We counted the number of transitions between the information category and remaining categories (i.e. requirement, solution, strategy) for each designer in the LRSs and HRSs sessions. Figure 6 shows the average number and average percentage of such transitions in the LRSs and HRSs sessions. A transition is seen when a segment of one category is followed by another category. In calculating average percentage of transitions, we first calculated average percentage of transitions for a given designer from the total number of transitions of that designer. Using these average percentages of transitions for each

designer in a session, we calculated average percentage of transitions for that session. For example, a transition from the category 'information' to 'strategy' was made 1.4% of the time in the LRSs sessions, and 0.9% of the time in the HRSs sessions (see Figure 11).

	LRSs				HRSs			
	Ave. No.	Ave. No. SD	Ave. %	Ave. % SD	Ave. No.	Ave. No. SD	Ave. %	Ave. % SD
Req to Info	8.8	7.3	9.4	2.6	6.8	3.1	8.1	3.2
Info to Req	9.5	9.3	8.8	4.9	6.3	1.7	7.8	3.5
Sol to Info	4.5	3.1	5.2	2.5	3.5	2.4	3.8	1.9
Info to Sol	4.5	2.6	5.7	3.8	4.0	1.8	4.5	1.0
Str to Info	3.0	4.2	2.0	2.8	0.8	0.5	1.0	0.7
Info to Str	2.0	2.8	1.4	1.9	1.0	2.0	0.9	1.9

Figure 6 Average number and average percentage of transitions associated with information category (Req - requirement, Sol - solution, Info - information, Str - strategy; Ave. - average; SD - standard deviation)

Figure 7 shows the transitions between the category – information – and solution-specific requirements (SRs) and solution-neutral requirements (NRs). In both LRSs and HRSs sessions, the average percentage of transitions between the information category and NRs is higher than those with SRs. Because SRs are related with solutions, it is likely that transitions between SRs and solutions will occupy a greater proportion than those between SRs and information. The occurrence percentages of transitions between the information and NRs are higher in the LRSs sessions than in the HRSs sessions (see Figure 7).

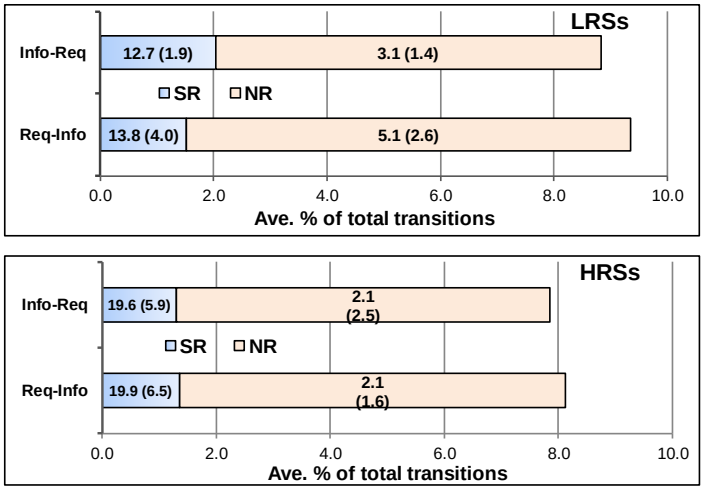

Figure 7 Transitions of information category with solution-specific and solution-neutral requirements (SR: solution-specific requirement, NR: solution-neutral requirement, standard deviation values are presented in brackets)

5 SUMMARY OF FINDINGS AND DISCUSSION

Using protocol analysis, we explored the differences between the informational behaviour of the designers in LRSs and HRSs sessions. To explore these differences, we compared informational behaviour of designers who worked on a design task for the LRSs with the designers who worked on the same design task for the HRSs. While we acknowledge individual differences between these designers, as manifested in the standard deviation values presented in the findings, we can recognise trends revealing differences between their informational behaviour.

The LRSs designers spent more time in dealing with information than the HRSs designers as indicated by the higher average percentage of segments associated with the 'information' category in the LRSs sessions. Furthermore, the findings reveal that the average percentage of transitions between information and other categories (requirements, solutions, and strategy) is higher in the LRSs sessions than the HRSs sessions. This suggest that the LRSs sessions were more information intensive.

The findings reveal differences between the informational activities of LRSs and HRSs designers, e.g. LRSs designers preferred to ask for information over assuming information, indicating their low confidence in assuming information. While LRSs designers were less confident in assuming information, HRSs designers were more confident in assuming information, as suggested by their higher preference to assume information than asking for information. In addition to these differences in the activities of asking for, and assuming information, the findings show that the LRSs designers repeated more information than the HRSs designers. These findings indicate that the degree of unfamiliarity with the design task was greater in the LRSs sessions than the HRSs sessions. This interpretation about the degree unfamiliarity is further supported by Hertzum and Pejtersen's (2000) finding that designers prefer to ask for information when they face unfamiliar issues. Although the LRSs and HRSs designers respectively have experience of working on design projects for the LRSs and HRSs, there was higher degree of unfamiliarity with the design task in LRSs sessions. This can be attributed to the fact that the LRSs designers came from strata of the society other than the LRSs; thus lacking experience of living in the LRSs and of experiencing poverty. They thus had less direct knowledge of LRSs, resulting into higher degree of unfamiliarity with the design task in the LRSs sessions. Further research can be undertaken to support designers in their informational activities (e.g. asking for information) when they design products for unfamiliar contexts. It would also be interesting to understand informational behaviour of designers when they work on a familiar and an unfamiliar design problem for the same resource setting.

Development of different types of design skills demands working on a range of design problems with varying task environments (e.g. Cardella et al., 2002; Atman et al., 2005). The present research revealed differences between the informational behaviour of designers when they work on the design task for the LRSs and HRSs. These differences show that solving design problems for the LRSs can potentially change the designers' informational behaviour, supporting them to practice and improve a different set of skills. Providing students with opportunities to work on LRSs design projects might usefully assist them in practicing and developing skills necessary to design products and services for unfamiliar contexts, and to enhance knowledge and skills required to handle design tasks that are information intensive.

As with any research method, this research has limitations associated with the method that we have used, namely the think aloud protocol analysis. The results are based on laboratory experiments, asking designers to work individually on an artificial design problem, with limited amount of time. The experiments used the researcher as the only source of information. The 'real life' design projects, in general, are carried out by teams, tackling 'real world' problems. Although the sample size in the present research is small, the experiments allowed collecting sufficient data to reveal overall trends. It is important to collect and analyse data from 'real' design projects in LRSs, using a variety of data collection methods, in order to generate design knowledge in the scarcely researched field of design for LRSs.

6 CONCLUSIONS

Designing products for LRSs is critical to satisfy unmet or under-served needs of the people who are poor. Supporting designers to enhance the chances of designing successful products for LRSs, typically plagued by complexly intertwined constraints, warrants an in-depth understanding of their informational behaviour. In this study, using protocol analysis, we compared informational behaviour of designers in conceptual design of products for LRSs and HRSs. Our exploratory study revealed differences between their informational behaviour, suggesting the potential influence of market-context on the designers' ways of handling information in the design process.

The designers who worked on the design task for LRSs spent more time in dealing with information than the HRSs designers, indicating information intensive nature of product design for LRSs. The findings indicate differences between the informational activities of LRSs and HRSs designers. The degree of confidence in assuming information was lower in LRSs sessions than HRSs sessions, with higher preference in asking for information in LRSs sessions. This suggests higher degree of unfamiliarity with the design task in LRSs sessions despite the LRSs-designers' experience of working on university-based design projects for LRSs. This indicates that lack of prior experience of working on LRSs-design-projects is likely to generate even more higher degree of unfamiliarity in LRSs design tasks.

The findings of this research have implications for design education. It is important to provide opportunities for students to work on LRSs design projects, this can assist them to develop knowledge and skills to handle information intensive design tasks and to design products for unfamiliar contexts. Finally, we believe that to generate more knowledge on poverty and in particular about designing interventions or products to alleviate it, there is a profound need of extensive design research in this field.

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