Identifying and Measuring Cultural Differences in Cross-Cultural User-Interface Design

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Abstract. This paper is investigating the role of culture in cross-cultural user interface design, and particularly focused on e-banking user-interface design. The results of this research are presented in two phases. The first phase is focused on the development of a cultural model that has some HCI factors. The second phase introduces the Cross-Use experiment that aims to evaluate the mapping between website design elements and cultural attributes using a user-in-context evaluation approach. This is done by developing three User Interface designs, and applying them to 63 local participants from the case study cultures (Brazil, Kuwait, Egypt, and UK). The experiment was conducted using the developed prototypes was able to classify cultures differently, and highlighted those design markers that affects cultural differences in the design of e-banking websites. This is based on user preferences and usability.

Keywords: Culture, Usability, e-banking, user-in-context evaluation.

1 Introduction

The growth of internet-based software and services and the continued globalisation of businesses present new challenges for developing user-centred design. One of these challenges is how to understand and analyse cultural diversity between user groups and how to design user interfaces that accommodate this diversity. In this paper we are concerned with one particular aspect of this problem, which is how to support the design and development of usable systems across national cultures. Currently, designers are not equipped with tools that support culture-sensitive design [8, 21]. There are no guidelines yet published that guarantee international usability [10]. Many cross-cultural designs use existing websites designs in identifying cultural design differences. However, most of these designs are not supported with a cultural model, or adopt cultural models that are not design oriented for interpreting design based on culture [5, 6, 7, 8].

This paper is part of a research investigating into the role of culture in cross-cultural user interface design (Culture-Centred Design approach as an extension of user-centered design)[9], and focuses on e-banking user-interface design. The paper presents the results of a study that has been developed into two phases. The first phase

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(see Section 3) involves the development of a cultural model that has some HCI factors based on 28 Cultural Attributes (CA) identified from cultural models literature. These attributes seems to show some relations to interface design that could present significance differences for the studied culture. The result of the first phase is in the form of design analysis that incorporates factors that play significance role in developing a cultural model for interactive interface.

In the second phase (see Section 4), the design analysis was used to design prototype websites for three countries these are Kuwait, Egypt and UK in e-banking domain. Usability studies in each of these countries were conducted, involving native users who empirically asses the level of the culture usability we have achieved. In this phase, a rigorous approach was adopted to determine whether these websites were in fact more usable or preferred by target users. We have also investigated whether websites designed for different cultures could lead to some usability problems or less preferences through the Cross-Cultural Usability experiment (phase 2).

2 Cross-Cultural Studies and Cultural Models

There are numerous approaches to the analysis of national cultural diversity from many disciplines such as psychology, sociology, and others [3]. There are also many approaches to the analysis of interface usability across cultures [5, 14]. These can be summarized as three strategic approaches. The first approach is the model-based approach that incorporates cultural models developed by other disciplines to understand the value systems, attitudes, experiences and expectations of the targeted national cultures. These models use survey and observation techniques to identify generic parameters, and determine where a particular national group is positioned in the space defined by this set of parameters (e.g., Hall [1]; Hofstede [4]; Victor [2]; and Trompenaars et al, [6]). The second approach is targeted specifically at interface design and employs inspection techniques designed for analysing interfaces that are used by particular national cultures in order to infer which interface components are particularly sensitive to cultural effects [5, 21]. The third approach is aimed at interface design and is based on user studies.

Cultural model is a set of cultural variables that is used to compare the similarities and differences between users' groups and/or cultures [3]. The cultural variable is a means of presenting the different categorizations that might cultural data contained. In this research the focus will be on national culture differences. This paper focuses on the four well-known cultural models as described by Hoft [3]. These are: Hofstede [4], Hall [1], Victor [2], and Trompennars [6]. Section 3 will show how to create a cultural model applying principles from HCI perspective.

3 Cross-Cultural Evaluation – Phase 1

As discussed earlier, most of the cultural models used within HCI research studies tend to understand and study culture based on non-HCI disciplines. In this study, we belief that in order to improve the study of culture in HCI, the creation of a model of culture that is HCI oriented is important. Therefore, this research aims to exploit these cultural models by exploring the effects of these models on UI design and usability.

3.1 Questionnaire Design and Data Collection

Questionnaire was used to collect the cultural data required to build up the cultural profile. The cultural attributes (CA) (28 CA's, see Table 1 in [9]) used in this questionnaire were derived from the cultural models founds in the literature [1-4, 6]. These specific CA's are the characteristics of CA are selected based on their suspected relation with the design of artifact UI. These CA are composed the three design dimensions model: Interaction information (I), Information or task processing (T) and Artifact-User relationship building (R) (Further details on 3-D model see [11]). The 28 (CA) are the dependent variables, while the independent variables are data such as nationality, sex, age, education, country, languages, and religion. The questionnaire was validated through a pilot study and three version on the questionnaire was developed (UK and Brazil questionnaires are in English, and Egypt and Kuwait questionnaires are in Arabic but different designs).

Table 1. Cultural Attributes

I1. Information Amount [1,2]	R1. Relationship type [1,4]
I2 Information Type [1,2]	R2. Rules expressing *and* Decision making [1,3,4,5]
I3. Information travelling [1,2]	R3. Cultural awareness (or adaptation) [1,2,3]
I6. Translation Language [2]	R5. User experience [5]
I9. Source of Information [3,4,5]	R7. Communication medium [2,3,5]
I10. Information Diffusion [3,5]	R8. New technology [2,3]
T1. Personal Space (Trust) [1,3,6]	R10. Relationship symbols [2,3,4,5]
T2. Task performance [1,3]	R11. Externalizing (expressing)
T7. Task organizational goal [3,4]	R12. Security sensitivity [5]
T8. Lack of expectation [1,4]	R13. Credibility [1,2,3]
T10. Goal achievement speed [1,3,4]	R15. Work Quality [3,4,7,8]
T11. Task rules compliance [3,5]	R16. Authoritativeness [2,3,4,5,7]
T12. Task medium preferred	R17. Gender Role [3,4,7]
T13. Information structure and navigation [3,4]	R19. Reputation [3,4,5]

Cultural profile is reporting the questionnaire data based on cultural differences. Cronbach's Alpha values shows that the questionnaire is high reliable ($\alpha = .75$, $n = 709$). The data collected involved 706 participants from diverse background, mainly in universities involving Kuwait (156, 22%), Egypt (303, 43%), UK (150, 21%), Brazil (97, 14%).

3.2 Results

3.2.1 Total Score for Cultural Profile

The data of participant's were entered into one-way ANOVA. The results show a significant difference among the nationalities in total score of cultural profile questionnaire ($F(3, 705) = 488.2$, $p = .000$). The result of Tukey HSD shows each nationality has significant difference with other nationalities in the total score of cultural profile questionnaire ($p > .001$). The differences among the nationalities in cultural

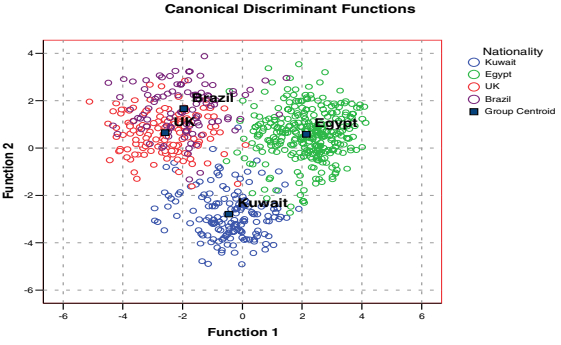

Fig. 1. Canonical Discriminant Functions plot: visualizing how two functions discriminate between groups by plotting the individual scores for the two discriminant functions.

profiles are clearly illustrated in a separate-group graph (see Fig. 1). The Discriminant Analysis (DA) Function classification result shows that it correctly classifies 89% of the cases. DA gets almost most of the Kuwaiti (94.2%), Egyptian (96.7%) and UK (86.7%) cases correctly classified. However, Brazil was less with 59.8% correctly classified and 42.2% misclassified and most of misclassified cases go with the UK (32%) and very less with other nationalities (Egypt 6.2% and Kuwait 2.1%). These results present a satisfactory DA.

3.2.2 Factor Analysis (FA) on Items of Interaction Information Dimension

The results of FA on items of interactive information shows there is just one factor in this part of cultural profiles questionnaire. All questions (I10, I2, I9, I3, and I1) of this part of the questionnaire have highly loading just in one factor. The results show there are significant difference in nationality ($F(3, 706) = 56.484$, $p = .000$) and religion ($F(3, 706) = 1.456$, $p = .034$) in mean of the factor. The Tukey HSD test shows there is no significant difference between Brazil and UK ($p > .05$), others are significant $p = 0.00$.

3.2.3 Factor Analysis (FA) on Items of Information or task processing Dimension

The results of FA on items of Information processing (or task processing) shows there are three factors - *Task organizational goal*, *Information structure and navigation*, and *Personal Space (Trust)*. The results show significant difference in nationality in factors of task processing: factor task clarity ($F(3, 500) = 38.5$, $p = .000$), task structure ($F(3, 623) = 13.06$, $p = .000$) and factor task sequence and trust ($F(3, 935) = 5.31$, $p = .001$). The Tukey HSD test for the *Task organizational goal* factor shows no significant difference between Brazil and Egypt ($p > .05$), while other interactions were significant ($p = .000$). The Tukey HSD test for the *Information structure and navigation* factor shows all nationality interactions are significant ($p < .05$). The Tukey HSD test for the third factor *Task Personal Space (Trust)* shows whereas there is a significant difference between Brazil and other nationalities ($p < .05$), other interactions were not significant ($p > .05$).

3.2.4 Factor Analysis on Items of Artifact-User Relationship building Dimension. The results of FA of user-artifact UI relationship shows there are four factors in this part of cultural profiles questionnaire. These factors are: *Authoritativeness, Relationship symbols, Rules expressing and Decision making, Credibility.* The Tukey HSD test for the *Authoritativeness* factor shows whereas there is not a significant difference between Brazil and UK ($p > .05$), other interactions were statistically significant ($p = .000$). In the *Relationship and Symbols* factor, the results of Tukey HSD test show UK has significant differences with other nationalities ($p < .05$) but there are no differences among other nationalities ($p > .05$). The Tukey HSD test for the *Rules expressing and Decision making* shows there is no significant difference between Brazil and Egypt ($p > .05$). However, other interactions of nationalities were significant ($p = .000$). Finally, in the *Credibility* factor, the results of the Tukey HSD test shows whereas there is no significant difference between Brazil and UK ($p > .05$); other interactions were statistically significant ($p = .000$).

The factor analysis resulted in the identification of eight factors that play significant role in developing a cultural model for an interactive interface and these are: *Interaction information*, *Task organizational goal*, *Information structure and navigation*, and *Personal Space (Trust)*, *Authoritativeness, Relationship symbols, Rules expressing and Decision making, Credibility*. These variables are used in the design analysis to develop a number of possible prototype websites. However, all these variables need to be culturally adapted to some degree. In order to decide between designs alternatives, a user testing approach was conducted (Phase 2).

4 Cross-Use: Cross-Cultural Usability User Evaluation – Phase 2

The design analysis results from the first phase are used to develop possible prototype websites that are culturally adapted for the Cross-Use experiment. The aim is to evaluate the mapping between website design elements and CAs using a user-in-context evaluation. The experiment design involves three national cultures, using three UIs for simple and complex tasks (3*3*2 mixed design). The prototype was developed based on the results of the design analysis. The 3 websites developed have one UI design for each culture that maximizes the cultural and genre attributes appropriate for that culture. 84 user variables are measured in this experiment (details in [9]. The experiments were conducted with 21 participants from each culture (Kuwait, UK, and Egypt) and they must be able to use the computer, internet, speak English

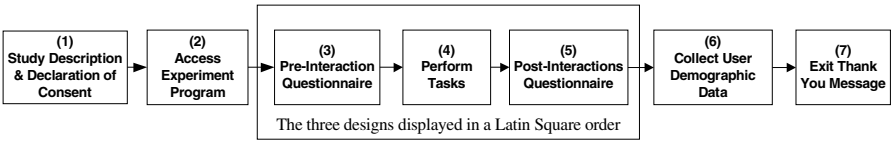

Fig. 2. Cross-Use experiment procedure

and were paid. The experiment has 7 stages (refer Fig. 2). In 1st stage, participants were given details about the three experiments. For the 2nd stage, they receives two 3-digit personal account codes and a password for them to run the experiment process

and perform the online transactions. In the 3rd stage, a questionnaire was administered and during the 4th stage, participants perform 6 tasks, which are divided into 2 task groups. In the 5th stage, the participants were presented with several design layouts, and transactions processes, and were asked design questions to rank cultural design claims. Stage 6 ends the experiment. The experiment uses a laptop running (local webserver) with webcam Morae™ tasks recording tool.
The objective of the Cross-Use experiment is to substantiate the cultural design claims [9]. In order to test these objectives, several analysis methods were conducted, to examine the validity of the following hypotheses:

H1: Users will prefer the website designed for their own culture.
H2: Better usability results are achieved when websites designed for specific culture is tested by members of that culture.
H3: Using DA, it is possible to identify specific or aggregated DMs that are the main contributors to the observed user preferences and usability improvement.

The DA and Chi-Square statistical methods were used to analyse the data. DA shows the most important variables that discriminate the dependent variable or affect it, while the Chi-square is used to determine whether the groupings of cases on one variable are related to the groupings of cases on another variable.

4.1 Results

4.1.1 Cross-Cultural Design Preferences

Hypothesis (H1) predicted that when creating designs that are in accordance with cultural design claims [9], these designs are able to generate culturally sensitive designs. DA was performed with national culture as the dependent variable, and the DMs as independent variables. The results of this analysis confirmed hypothesis H1 (see Fig. 3 and Table 2). This indicates the ability of the website designs that adopted the cultural design claims to design for different cultures to capture users' preferences. The DMs that cause the cultural preference differences among specific national cultures resulting from the above DA test are shown in Table 2.

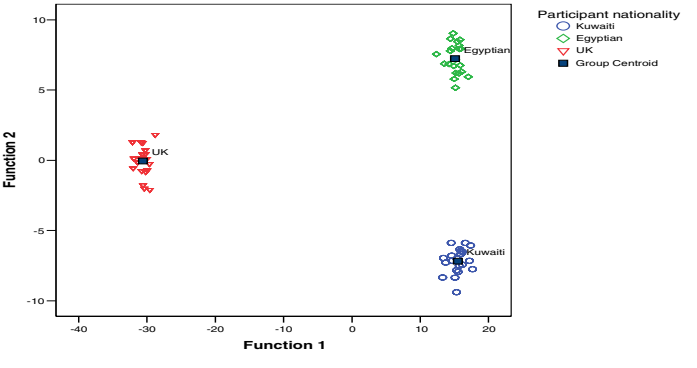

Fig. 3. Canonical Discriminant Functions plot: visualizing how the two functions discriminate between cultural groups by plotting the individual scores for the two functions

Table 2. Partial summary table for the user preferences DMs

CA	Claim	Design markers	KU	EG	UK	Related Question
R6, R7	C16	Religious Metaphors (Design A)	M	M	L	B2a (*)
T4	C21	Drop-down Menu (complex navigation)	H	M	H	A1a (*)
		Tree-view (complex navigation)	L	M	L	A1b

Legend
CA is refer to the cultural attribute code identified in the HCI-cultural model [see 10]
- Low (L): <2.49; Medium (M)=2.50..3.49; High (H): >3.49
- (*) DM identified to be significant (p<.001) based on both the DA with Univariate ANOVA tests

4.1.2 Cross-Cultural Design Usability

In this section, an investigation of a good representative score for the cultural usability factor is conducted. Then, two types of analysis are performed - Chi-square test, and DA. Chi-squared analysis shows that there is a significant relation between national culture and design usability (χ^2=19.08, df = 4, Sig. < 0.001). In Fig. 3, certain website designs are found to be more usable by certain national cultures is shown.

Discussions on validating hypothesis (H2) are based on Fig. 4, which shows a clear tendency for high usability by Kuwaiti participants in using their cultural design (design-A). But there is an exception to the hypothesis for Egypt and UK. Egyptian participants show high usability in using design-A, while UK participants have a usability score that is split between design-B and design-C. To further investigate the cause of this, in the following section, the DA is used to identify which specific variables were affecting usability scores for each of the cultures.

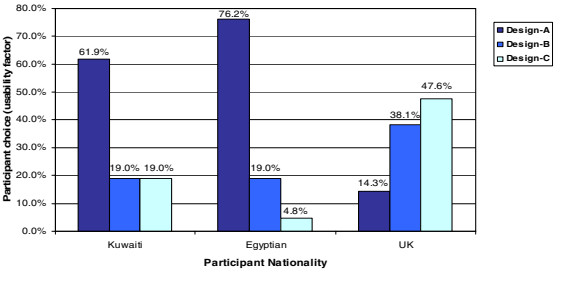

Fig. 4 The distribution graph for the usability scores according to culture and design

DA provides two types of result. The first is the classification of the three designs (A, B, and C) based on the usability factor for each case study culture (to determine the usability level on different designs). The second is in identifying the DMs, which cause usability improvements among specific national cultures as shown in Table 3. The DA results shows that the total validity of the proposed model is 100% for observations, which indicates that all cases were adequately categorized in all cultures. However, the design classification based on usability factor across cultures shows that design-A seems not to discriminate between Kuwaiti and Egyptian cultures. This

confirms the results shown in Fig. 4, which stresses that at the cultural usability level, Kuwaiti and Egyptian participants show some similarities in usable DMs. This indicates that, based on usability, Kuwait and Egypt could share design-A and that the UK site (design-C) should be redesigned to have cultural DMs from design-B, in addition to design-C DMs. Thus, study hypothesis (H2) is partially confirmed for Kuwaiti culture.

Table 3. Partial summary table for cultural usability DMs

CA	Claim	Design marker	KU	EG	UK
		Relationship Metaphors			
R6, R7	C16	National Metaphors (Design B)		H†	
		Navigation tools			
T4	C21	Drop-down Menu (complex navigation)	H†		H†

Legend
† This symbol indicates that this DM affects usability for this particular culture (presenting a cultural-usability design). The result of this indicator is determined by performing DA.

The summary of DA results shown in Table 3 shows there is a clear tendency to identify specific DMs that are the main contributors to the observed participants' usability. Hence, H3 is confirmed for identifying the DMs for usability. This indicates the ability of the DA to identify the DMs that affect usability. These DMs are used as user-in-context based evidence in supporting or contradicting the cultural design claims. Reviewing the complete list of the usability DMs (see [9]) indicates that the shared DMs and cultures, based on the cultural usability factor shows that there are more shared cultural usability DMs between Kuwait and Egypt, followed with Kuwait and UK. However, between Egypt and UK, there are no shared DMs. This confirms the relation between Kuwaiti and Egyptian cultures discussed earlier.

5 Discussion and Conclusion

The general inspection of the two phases' results indicates that many CAs identified in the HCI-Cultural model affect usability, especially those attributes identified by the Factor Analysis in phase 1. The results show cultural differences when cultural attributes were transferred to design markers and tested by users from different cultures in phase 2.

The Cross-Use data analysis was presented through two models: (1) the cultural preferences model, which consists of the high level classification and DMs of cultural preferences, and (2) the cultural usability model, which consists of the high level classification and DMs of cultural usability. Both models have different concepts that require various analysis techniques, which produce diverse results and significance levels. The cultural preferences model concept was to identify whether the participants' preferences for using the three designs are different, where the experiment shows there are significant differences. This proves that the experiment designs were able to classify cultures based on participants' preferences for the DMs, which at one level substantiates the experiment design and on the other level shows that there are

cultural design differences. In addition, this model shows that a high number of the identified DMs are culturally preferred, which indicates that most of the DMs can be differentiated based on participants' preferences.

The next challenge here was to see whether the usage of culturally preferred DMs in local designs improves local design usability. The cultural usability model was developed based on how the user performs the assigned six tasks. In this case the usability factor was developed to discriminate between the studied cultures. Based on this model, several issues were identified: there is a high relation between culture and design usability using the three designs. This indicates that the three designs were able to identify a relation between culture and usability, which shows that at the classification level culture preferences are able to make usable designs. However, based on the most usable design related to culture, the results show that the Egyptian culture reflects design-A as the most usable design compared to the earlier expectation, which is design-B. In addition, the UK participants shared both design-C and design-B as they are the most usable designs. Therefore, the cultural DMs based on usability are not the same as the cultural design claims. These findings motivate the investigation of cultural usability DM.

Earlier, design preferences and usability were discussed to determine their differences. Then, during the experiment evaluation, these two issues were tested using a process to evaluate users. The question here is whether the websites that have been designed based on user cultural preferences are necessarily presenting usable design. The answer to this question helps in recognizing the sensitivity of the approach in collecting data that provides results to help in delivering usable design. The study of Evers and Day [3] uses the culturally extended Technology Acceptance Model (TAM), which uses the usability variables such as usefulness, ease of use, and satisfaction to determine the UI acceptance. They use questionnaires to collect users' preferences. Their study indicates that design preferences affect interface acceptance across cultures. In the Cross-Use experiment, the general view of the design classification based on the usability factor for each culture shows higher differences on cultural preferences than usability (see [9]). This proves that participants prefer design differently, but when they use the design, it shows more differences in usability than originally expected. This highlights the complementary usage of the user-in-context evaluation in determining the usable cultural DMs.

Many website developers and evaluators use methods that assess user preferences aiming to create usable design. For example, the Cultural Markers [5], Website Audit [8], and user evaluation [10] using questionnaire based tools only are not sufficient in understanding and identifying the appropriate usability requirements. According to the results of Cross-Use experiment, as can be seen from Table 2, which presents user preferences CMs, and Table 3, which presents usability CMs, the comparison between the two markers indicates that the number of the identified markers in each type is different, and the identified markers based on preferences are not necessarily identified based on usability and vice-versa. The cultural usability model identifies fewer DMs than in the cultural preferences model. These prove that not all of the preferred DMs are necessarily usable DMs. Furthermore, the cultural usability DMs show that there are some DMs that are not shown to be preferred by the participants but are statistically proven to improve usability (e.g. Tree-view navigation DM in claim C21, as shown in Table 2 and Table 3). This suggests that research based on

design preferences does not necessarily present the effects of usability as indicated by Constantine and Lockwood [4]. As a consequence, the results of such studies linking participants' preferences to design can be doubted, and this also affects the investigation of existing website design, as both adopt the same results. Therefore, the results obtained from users' preferences and usability should scale differently in supporting cultural design claims and in the later stages of the development of cultural design guidelines.

This conclusion strengthens the research results as they are obtained by evaluating both the cultural preferences and usability DMs. For the future research a detailed inspection method are expected to be used to analyse these results together with results of earlier research studies, which aims at developing evidence-based cultural design guidelines and recommendations.

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