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User Centered Design for Adaptive E-Learning Systems

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Abstract: As the recent focus of using E-Learning Systems (eS's) has been increased and Internet has become more accessible, the quandary of designing efficient eS's becomes more severe. The diversity of users within a group, sharing an eS having their individual abilities, interests and needs challenge the designers of an eS's with heterogeneous needs for Adaptive User Interfaces (AUI's). These tribulations of designing eS's resulted in the creating of Adaptive E-Learning Systems (AeS's) which serve a specific set of user characteristics, in which the system or the user render its components and interface according to different requirements. This study has offered a brief overview of the eS's and the AUI's. In the same time we have pointed out existing and major problems for the designing of eS's. Hence we have conducted a research study for the profiling of eS students from three different countries UK, India and Iraq. In particular we have explored the collected data and what it tells us about the implications and variability of designing AeS's. Subsequently from this study we made an exhaustive conclusion followed by usability requirements summary, which indicates the required usability level for each country. Findings show that the differences in the general, user and usability characteristics of the students profiles, can principally affect the designing of eS's. Eventually from the derived analysis and conclusion, we argue that AUI's is a major component and the core of AeS's and there is an existent need for precisely defining user profiles by following a user centered approach.

Key words: User profile, AUI, AeS, knoelidge gap, usability requirements

INTRODUCTION

One important area that is problematic and subjective for achieving adaptively in the design is the designing of eS's[1]. It is currently a hot research and development area. A challenging research goal is the development of effective AeS's that satisfies individual needs[2]. Many new users expect the interacting with a system to be as natural and intuitive as interacting with a person, but current interfaces are artificial and constraining[3]. Therefore AUI's are a key factor for the success of any computer application and assume an enormous importance in the case of eS's.

According to Kobsa[4] AUI's have shown their promise supported by experimental studies in several application areas including recommendation systems and eS's and content-based, social and collaborative information filtering. As different users have different background knowledge, styles, preferences, intentions and other characteristics, they expect different user interfaces that satisfy their individual needs.

This diversity of users and the generality attribute of eS's resulted in creating different profiles for each group of users for eS's. The primary objective or purpose in building adaptive systems is quite clear: to improve the human-computer interaction[5]. Therefore E-Learning has to keep the people it's designed for in mind by effectively meet their needs. These needs can be satisfied by creating different profiles for each group of users. With good design, E-Learning can achieve these objectives. But most interpretations focus on the technology (the e) rather than the design of such systems[6].

User profiling-rendering user interfaces: User profiling is used to find users information, such as characters, interests and preferences, to acquire the most complete picture of the user[7]. This information, so-called user profiles can help in improving the design of eS's and customizing the content to the needs of specific users[8]. User profiling is one of the most critical factors for the success of designing AeS's. Understanding these needs in a rapid fashion has arisen as project timelines have shortened and the pressure has mounted to deliver value early and often. From cultural dimensions to computer expertise, the more you know about your users and profile these users, the easier it becomes to design for (and communicate to) them.

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We cannot develop effect AUI systems until we study, analyze and collect some critical information about the user characteristics, which relevant to user interface design. A clear, accurate sample of users is required to capitalize on the chance of defining the large number of common attributes of specific type of users. Adaptive systems have the ability to adapt themselves either to the user or to the situation. A system is called user adaptive if it is able to change its own characteristics automatically (adaptive user interface) or manually (adaptable user interface) according to the users needs[4]. Modification of interface presentation or system behavior depends on the way the user interacts with the system[9].

Among many researches having this, adaptation to user is very attractive to achieve the intelligent user interface[10-14]. To make the adaptation, knowing the current state of the user is fundamental. It is also an important task to know what type of users is now using the system[15,16]. The user's intentions, context, knowledge, skills and experience are the essential things that every designer needs to know. Without this, the team is going to design something that seems useful, but they'll never know if it actually helps the user. The best approach to achieve adaptation is to profile the user into groups[15-17].

We call the group a type or profile and we adopt the more exact definition of a type as users group in which users have similar properties such as their response to the same situation.

One approach is not sufficient for designing eS's. But most software systems treat all users as the same one size fits all. This means that various designed systems can be customized by setting some high-level designed parameters[18]. But this process is manual, tedious, requires user to be aware of preferences. So the better that we designed systems that can adapt to automatically user needs. Adaptive systems are designed to tailor a system's interactive behavior with consideration of both individual needs of human users and altering conditions within an application environment[19].

However every so often the task of user profiling is costly especially if conducting for offshore countries[20]. To cut and save these costs, some companies are conducting the user profiling task remotely (by which designers test users from far distances for usability problems and then convert these findings into user profiles) or what called offshore usability testing. But this process is difficult due to: (1) lack of interaction designers and usability professionals (2) the other is more fundamental deeper problem of separating interaction designers and usability professionals from the users. User-centered design requires frequent access to users the more frequent the better. Two possible solutions to overcome these difficulties (1) The lack of user testing might be alleviated by running tests with local users (2) balancing usability testing with the user of heuristic evaluation[21].

The designed system must be adapted to user needs that support different perspectives of users. For this reason we should define the scope of our intended users by creating a detailed profile for each group of users, which contain some critical information, related to the user interface. Therefore AUI utilize the knowledge about the user to configure the interface for different users by creating distinct profiles for each group, i.e. each user may have different skills, level of experience, or cognitive and physical abilities[22].

ADAPTATION IN E-LEARNING SYSTEMS

The design problem: While a large number of organizations have adopted eS's, far fewer have addressed the eminence of usability. More attention should be devoted to assuring the usability of eS's if organizations are to fully benefit from their investments.

A good user interface should render the eS usable by its users. In this sense the user interface can be thought of as something, which sits between system and user and adapts the system to the user. Hence, if a user finds an interface difficult to use then the interface has not fulfilled its purpose for that user. Similarly, when circumstances change, a previously well AUI may become maladapted to the new situation[23]. One particular weakness with most interfaces is their static nature[24]. Programmers create these interfaces to interact identically with all users and for a range of tasks, without considering differences in knowledge, preferences and purpose. At best, some interfaces allow limited customization by explicitly setting preferences and options.

Therefore AUI are a promising attempt to overcome contemporary problems due to the increasing complexity of human-computer interaction field[5]. In other words the goal of adaptation is to present the human user with an interface that is easy, efficient and effective to use. To reach these goals it is necessary to provide a user with an interface suitable for changing either: (1) the way it communicates with the user (2) the system functionality provided on the basis of the individual characteristics of the users[25,26]. AUI must cope with the heterogeneous between and within users by designing interfaces that is adaptive[4]. Achieving this in eS's in not direct and easy. There are several reticence and difficulties when designing AeS's such as: (1) the generality attribute of users in an eS's (2) the requirements elicitation problems when attempting to capture the actual needs of user

Fig. 1: The knowledge space gap

profiles[27] (3) the testing problem in adaptive systems (4) the evolution of adaptive systems is very difficult (5) it is difficult some times to integrate all of the users requirements and characteristics (6) costing problems as mentioned above in section 1 (7) the development of adaptive systems suffers from that there is no fixed methodology or standard process for developing adaptive systems. In order to comprehend that, we have to look at how people understand the design in the first place. To do that, we need to look at the design knowledge space.

The knowledge gap: Users have different knowledge and experience when interacting with user interfaces. This knowledge may be normal as (current knowledge) or rich to (target knowledge). The distance between current knowledge and target knowledge of users has a technical name: The knowledge Gap. The Knowledge Gap is where design happens. We don't need to design to the left of current knowledge as point and shown in Fig. 1, because it's all stuff the user already knows. And we don't need to design stuff to the right of the target knowledge point, since the user won't need that information. We only need to design the interface for the space in between current knowledge and target knowledge as explained in Fig. 1.

The portion of the knowledge space was most concerned with when were designing AUI's. Users can complete their objective when current knowledge equals or very near to target knowledge. There are two ways or directions this can happen. You can train the user, thereby increasing their current knowledge, until they know everything they need to know, or you can reduce the knowledge necessary by making the interface easier, until target knowledge only requires the information the user already has. We will focus on the later object because making interfaces easier is in general the intention of adaptive systems. In other words we create systems based on user profiles. This will provide us a clear depiction between the complexity of design and the user profile richness. In order to elucidate our assumption, in Fig. 2 we have explained the opposite relation between the user profile richness and the design complexity of adaptive systems.

The design and implementation of human-computer interfaces is inherently difficult and time consuming,

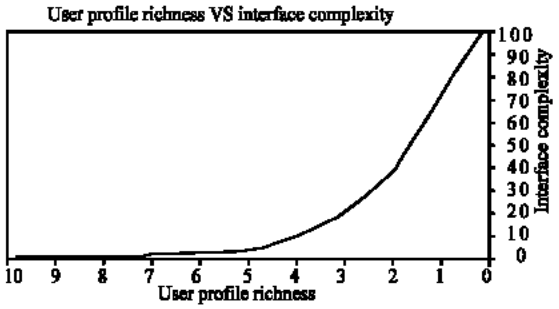

Fig. 2: User profile versus interface complexity

e.g.[28] and additional difficulties arise in the case of interfaces that are according to requirements of an interaction, thus creating the need for adaptive human-computer interaction, e.g.[29]. Adapting a user interface to its users needs is non-trivial task for the user interface designer. First they must recognize the variability in the needs of the users and show an adequate benefit in adapting to each variant. Then they must devise user interface designs adapted to each variant and have access to cues that indicate which variant of interface should be used in a given situation. And finally the must identify the agent of change.

In fact we will reverse the current perception of designing adaptive system and argue that both the complexity and user profiles are two critical factors for the AUI's. The design of adaptive systems require the more general view that there is a range of design solutions and that the choice of design solutions should be determined by the demands of the circumstances, or to put this view another way, conventional systems are special cases of adaptive systems in which the parameters have been pre-set.

RESULTS AND DISCUSSION

In order to clarify the value of the user profiling in AUI's we undertook an extensive research followed by a detail analysis. Information has been collected based on the set of national and international student's surveys. In addition we have concluded some indirect factors based on our own analysis that is vital for present study assessment. The research captured quantitive and qualitive critical information that is related to the AUI's. A total of 28 factors based on 15 surveys, categorized in 4 characteristics, which is either quantitive or qualitive. These results attempted us to create three user profiles from three countries, UK, India and Iraq. Precise data gathered for different categories in which captures the utmost disparities among student's profiles. Information

Table 1: Survey questions

No.	ID	Questions
1	Physical identifiers	1-Are you male or female: _____ M _____ F 2-How old are you: _____ 3-Are you color blind in any way: _____ No, _____ Yes(Explain_____) 4-Do you have physical handicaps other than vision deficiencies that need support: _____No, ____Yes(Explain_____) 5-Do you remember using computers when you use it next time: _____No, _____Yes(Explain_____) 6-Do you wear glasses or contact lenses: _____No, _____Yes(Explain_____)
2	Cognitive/ psychology identifiers	1-Have computers affect your job: _____Easier, _____Not effected, _____More difficult, _____Others(Explain_____) 2-Are you satisfied with using eS's: _____No, _____Yes, _____Other(Explain_____) 3-How much do you understand with the virtual courses: _____Nothing, _____Little, _____Much, _____Very much 4-In general do you accept eS's: _____No, _____Yes(Explain_____) 5-How much confidence do you feel when using eS's: _____None, _____Low, _____Medium, _____High 6-Do you have any creativity performances, awards, special achievements: _____No, _____Yes(Explain_____) 7-How much patient can you spend when using eS's: _____(Few Minutes), _____(Less than 1 Hour), _____(More than 1 Hour), _____(More than 2 Hours) 8-In general are you interested in eS's: _____(Not Interesting), _____(Interesting but as only means to help me), _____(I am interesting and enjoyed), _____Other(Explain_____) 9-Do you enjoy eS's learning: _____(Yes its interesting), _____(Sometimes depend on application), _____(No its frustrating), _____Other(Explain_____) 10-How much conclusions throughout building your understanding: _____Less) _____Moderate, _____High
3	Usability identifiers	1-Do you make errors when using eS's: _____No, _____Yes(Explain_____) 2-Do you find it easy to use eS's: _____No(Explain), _____Yes(Explain_____) 3-How much time do you spend to learn eS's: _____Very slowly, _____Slowly, _____high-speed, _____Quickly 4-What types of multimedia do you prefer: _____Text, _____Audio, _____Video, _____Mixed(Explain_____) 5-Which interaction style do you prefer: _____Command, _____Form Filling, _____Menu, _____Direct-manipulation, _____Other(Explain_____) 6-How much information density you prefer on the interface: ____Low density, _____Moderate density, ____High density 7-In general do you feel eS's is simple: _____Very Easy, _____Easy, _____Moderate, _____Difficult, _____Very difficult
4	Knowledge and experience identifiers	1-How do you describe you computer experience: _____Novice(Less than 1 year), _____Experienced(1-3 years), _____Expert(More than 3 years), _____Other(Explain_____) 2-How do you describe you Internet experience: _____Novice(Less than 1 year), _____Experienced(1-3 years), _____Expert(More than 3 years), _____Other(Explain_____) 3-How frequent do you use eS's: _____ No use, _____Little, _____Moderate, _____High 4-What is you qualification: _____No degree, _____High School, _____Trade, _____College, _____Graduate, _____Other(Explain_____)

has been collected according to the survey questions shown in Table 1 and the results of these questions has been summarized in Table 2, followed by a detail analysis and finally we summarized the usability requirements explained in Table 3.

In particular we have explored this data and what it tells us about the implications on designing eS. This factual case study gave us the opportunity in addressing the challenges of designing eS's by effectively profiling users. The overall goal was to understand the substance of these profiles and their needs for richness.

Research study: In this section we offered an exhaustive conclusion. This conclusion has been explained in three important characteristics: general, user and usability characteristics. These factors contain the critical information that is compulsory for the design of eS's. The student profiles are from UK, India and Iraq. Results from Table 2 has been concluded in the below analysis and explanation. The conclusion focus was on the usability characteristics as it's a decisive factor to the AUI's[20].

Students conclusion

UK students: Information has been collected from[30-34]. In addition we have also concluded some other indirect factors that are important for present study comparison.

General description: UK has a good quality education system comparing with the world. The circumstances and context creates the best environment of study. UK offers a great assistance for students. Most UK students are research and postgraduate students. E-Learning is not a new model in UK and have been practiced from many years. UK has a very large number of universities that offers dissimilar programs and most of them are eS's. In general UK students are categorized as high knowledgeable and experienced students.

User characteristics: General attitude and motivation of students toward eS's is very high, (85%) perceive eS's to be important and essential to their study process. They deem that technology is very important and mostly needed. The average age of UK students is between (18-40) this indicates that multi-levels of ages exist. The majority of UK students are both male and female, (51% male, 49% female); in general UK students are categorized as practiced students and they need little support or assistance.

Education level is high, by inference they are quick learning students. The number of computer and Internet experienced students in contrast is very high and the frequency of use is very high and significantly higher than other student profiles (India, Iraq), this is because the accessible technology services provided from UK. Most of the study system is automated; they are by innate experienced students. They are very interested in computers and have large enjoyment when using eS's this is because they are highly confidence students.

Usability characteristics: UK students do not need a high ease of learning and high ease of use of eS's systems. They expect different type of contents of

Table 2: Quantitive *(QN) and Qualitive *(QL) Research Information

No.	Factors Type		Students	Country Name		
	Physical	*QN. Data	Profile factors	UK	India	Iraq1
1	Characteristics		Gender (Average)	51% F, 49% M	42% F, 58% M	45% F, 55% M
2			Age (Range)	18-40	20-38	30-50
3		*QL. Data	Color blindnes	High blinded including Nearsighted, Farsighted, Wearing contact lenses	High blinded including Nearsighted, Farsighted, Bifocals, Wearing contact lenses	Low blinded
4			Handicapping	Low	High handicapped including Wheelchair, Arthritis In Hands, hard of hearing	Low
5			Memory (Storing)	Normal capability	High capability	Normal capability
6			Weaning (Glasses)	High	High	Moderate
7	Cognitive/ Psychology		Computing Effective	Effective 85%, Make it easer	Effective 70%, Make it easer	Effective 65%, Make it easer
8	Characteristics	QN. Data	Student satisfaction	Average No. of students Satisfied with eS's, 79%	Average No. of students Satisfied with eS's, 61%	Average No. of students Satisfied with eS's, 71%
9			Virtual course perception	Very understandable	Moderate to difficult	Very difficult
10			System acceptance	Highly accepted	Moderate accepted	Weakly accepted
11			Confidence	High confidence	Moderate confidence	Low confidence
12			Innovation (Creativity)	High awarded and Performance	Moderate performance, A few achievements	High performance
13		QL. Data	Patient capability	Moderate patient	High patient	Low patient
14			Interest in computers		High interested	Interested as only as means
15			Enjoyment	Always	Sometimes	Sometimes
16			Class vision (Technology)	Normal, objective	Sometimes	Frustrating
17			Reasoning capability high	Moderate	Low	
18	Usability Characteristics	QN. data	Error rate	Low error rate, 5-10%	Moderate error rate, 10-25%	High, error rate, 15-39%
19			Ease of use	Very easy	Moderate to difficult	Difficult
20			Ease of learn	Very quick to learn, Easy adaptable	Quick learning, adapt with time	Very slowly
21			Multimedia facilities (Text, audio, video)	Separate or mixed	Audio, video	All or mixed
22			Interaction styles	Command, form filling, Direct manipulation, menu	Form filling, direct Manipulation, menu	Direct manipulation, menu
23		QL. data.	System presentation (Content, density)	Expect high system density	Moderate to high density	Low density
24			Simplicity	Easy	Moderate to difficult	Difficult
25	Experience characteristics	QN. data	Computer literacy	High experience students, Natural experience 85%	Good experience, occurrence 62%	Fresh experience, however improving 54%
26			Internet literacy	Excellent experience, 77%	Good experience 58%	Fair experience 39%
27		QL. data	Frequent of use	High frequent of use	Regular use	Casual users
28			Degree (Qualifications)	Research, PG degrees, UG degrees	PG degrees	UG degrees

Table 3: Usability requirements summary

	Usability Requirements										
No.	Country	Ease of Learn	Intelligent interface	Enjoyment interface	Interface assistance	Ease of use	simplicity	Visual icons	Color vision	Troubles other than colors	Information density
1	UK			X			X	XX	XX	XX	XX
2	India	X	X	X	XX	XX	XX	XX	XX	X	X
3	Iraq	XX	XX	XX	XX	XX	XX	X	X	X	

* Blank = Not Important, X = Important, XX = Very Important

multimedia: video, audio, text. Student's looks at the quality part of the designed system, so they expected high quality eS's. Error rate is low; therefore they wish they could immediately grasp the functionality of these systems. They are easy adaptive with most of systems. They work with not as much of intelligent systems. Students need large and visual icons due to that large portion of UK have vision problems such as nearsighted or farsighted. In general the assistant of computer could be low because of the richness of their profile. They benefit from their high learning ability, work and interactions, however they have normal patient. They as well expect different kinds of interaction styles and they have the capability to work with high content eS's.

India students: Information has been collected from[35-38]. In addition we have also concluded some other indirect factors that are important for present study comparison.

General description: India students are from both undergraduate and graduate students. India has a lot of fine universities, established from a very long time and the educational is transforming to online learning slowly. Recently India has built a good Internet infrastructure that facilitates the using of eS's. In general India students are categorized as moderate and reasonable to other student profiles (Iraq).

User characteristics: General attitude and motivation of students toward eS's is high, (70%) perceive eS's to be

important to their study. The average age of India students is between (20-38) which indicates younger ages. The majority of India students are male and female, (58% male, 42% female).

The number of computer experienced students in contrast is from low to moderate. Frequency of use is from moderate to high and significantly higher than other student profiles (Iraq) and the frequency of use is most often discretionary. India students have a good experience of Internet rated from moderate to high. The diversity in languages and high memory capability is a high incentive toward eS's.

Usability characteristics: The ability to learn quickly and high memory capability is a high drive toward eS's. But qualitive data indicate that they lack in the understanding of eS's. They countenance some inhibition problems during the interactions of eS's. In other words some tacit problems arise when interacting with eS's. Error rate is moderate; they take pleasure in their interaction with eS's. In the same time they also expect low to moderate content of information. Data also indicates that there is improvement and motivation toward eS's. In general the assistant of computer could be low to moderate, which could be needed occasionally. In general data indicates that they are moderate students, but they need high assistance due to the large portion of India are handicaps which is either arthritis, wheeling chair, vision or have hearing problems.

Iraqi students: Information has been collected from[39-44]. In addition we have also concluded some other indirect factors that are important for our comparison.

General description: Most of Iraqi students are undergraduate students. No concerns in the education sector until recently due to a number of unstable situations the country has passed. Iraq has a lot of good universities, established from a very long time, but the educational and financial situation was not well provided. No Internet infrastructure was developed until recently. These critical factors did not give the Iraqi students the opportunity to sense such eS's. They have modest practical experience with eS's.

User characteristics: General attitude and motivation of students to eS is fairly high, but not high as other student profiles (UK, India). However nearly (35%) of students don't perceive eS's to be central to their study. The average age of Iraqi students is between (30-50). This average is declining, because of the recovery and stable situation currently in Iraq. The majority of Iraqi students are male and female (55% male, 45% female). The number of computer experienced students in contrast is low and considerably lower than other student profiles (UK, India). Frequency of use is quite low and significantly lower than other profiles and use is most often unrestricted. The same experience on Internet, low use of Internet because the way Internet way indulgenced. By inference they need a lot of intelligent and forgiving interfaces. Some support of technical people may be helpful. Data indicates they are low experience students and required very simple eS's however they are improving quickly.

Usability characteristics: Iraqi students have a very high need of ease of learning and use. They expect low system content presentation of multimedia video, audio and text that is adequate for understanding due to their limitation on eS's. Student looks at the plainness part of the designed system thus they expected easy understandable eS's. Less poise resulted that the designed systems must not require a lot of cerebral energy from the students and the system must absolve most of the student's errors (they also expect some features of intelligent interfaces). They have low patient therefore students expect a very rapid processing speed on the eS's, but other cognitive factors and characteristics offer them some quick grounding for eS's. In general the need of computer assistant is mainly necessary, because of their bright experience in using eS's.

Usability requirements: Eventually in this section we attempted to define the level of the usability for each country based on table-2 results and the above conclusions. Table-3 summarizes the usability requirements for each country based on 9 usability requirements.

The above usability requirements Table 3 probably in the future will be considered as eS's requirements, which take into account all the above characteristics. Determining usability requirements for any software system is not easy and straightforward. It requires a clear planning and accurate study on different user's characteristics and requirements. Therefore the need to follow a usability engineering approach is to maximize the opportunity of developing user centered software's, which fulfill both the users and the developer's intentions.

CONCLUSION

Adaptation is a universal problem among many disciplines and researches, in particular to individual

users is a challenging target because of the large differences and divergence that exist among users including their goals, their ability to recognize various types of information and their educational interests.

In this study we have analyzed existing problems of designing AUI's. The investigated results show that there is an existent need to precisely and strictly identify users profiles and make then sufficient to support users interactions. Both users and interfaces must be extremely considered when design AeS's. We argue that AUI's is a major and essential component and the core of AeS's and there is an existent need for specifically defining user profiles by following a user centered approach. Considerable work still remains to be carried out in this area, we suggest potential research work focusing on: (1) the inheritance of user profiles among other systems, sharing the same profile (2) inclination in designing effective self regulated eS's (3) the ability to define formal and standard methods for the development of such systems, this engross a clearer theoretical framework for understanding exact user needs.

We hope that present research, analysis and discussions will help learning researchers and developers of AUI's and eS's to better situate their research and developmental activities among the problems of designing user interfaces and address more issues of adaptation in eS's and to expand the conduction of experimental studies of user's characteristics and establishing more complexity design parameters.

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