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An Overview of User-centered Design Approach and Usability Methods in Product Development

Abstract

Product development requires a multi-disciplinary team's knowledge to accomplish the project. Its process normally involves the development and design of a new product in coherence with the plans for its market and production. Nowadays, to cope with users' increasing demands, the core concept of product development should not only be technology-driven. However, it should put more emphasis on user-centered approach, which is to place the user at the center of design considerations by focusing on different types of human factors including physical, cognitive, social, and cultural human factors. Collecting and analyzing information from the product's intended users is undeniably necessary for this approach in order to identify user requirements, needs, and expectations. Therefore, the article presented discusses the overview of user-centered approach including its philosophy and practice, as well as the aspect of usability which is currently the most recognized view of user-centered design approach.

Keyword: User-centered design, Product development, Usability methods

INTRODUCTION

User-centered design is a philosophy that places the user at the center of design considerations; it focuses on different types of human factors including physical, cognitive, social, and cultural human factors. User-centered design seeks to answer questions about users, their goals, needs, preferences, expectations, limitations, tasks, and behaviors, then use these findings to drive development and design [6].

USER-CENTERED DESIGN PHILOSOPHY AND PRACTICES

The goal of user-centered design is to attain usability of the product or service offered to users. This ensures that user needs will be satisfactorily fulfilled, with an improved total user experience, which supports a better return on business objectives [9].

Two examples of user-centered design methods employed in various design fields such as product, communication, and interactive system design, are task analysis and scenario building. Task analysis developed within user interface design, where the user goal and task is at the core of design consideration. Its market definition, user study, task analysis, competitor evaluation, design and walk-through, evaluation and validation, and benchmark assessment. The market definition stage identifies target audience and competitors, as well as determines the core user needs; it must be fulfilled to ensure the product success.The user study stage gathers and analyzes user information to identify assumptions with regard to their needs, goals, tasks, behaviors, preferences, expectations, and limitations, as well as their potential contexts and situations of use.

Then, task analysis is performed to identify and understand user goals and the tasks associated with different goals. This process will help to uncover the strategies, methods, and tools they use to perform the tasks, any problems they may experience, and any changes they would like to see. In the competitive evaluation stage, design strengths and weaknesses of competitors are assessed.

The results obtained from these analyses are used to create alternative solutions, which are further assessed by user feedback. The final solution is shaped by user input. To evaluate and validate the proposed design, users are observed with regard to how efficiently they perform tasks. Their feedback is gathered to iterate the design through incremental improvements. Eventually, to perform benchmark assessment, the final design is assessed against the competition to verify that the final product meets its primary objectives [3].

The International Organization for Standardization (ISO) also recognizes the importance of user-centered design. In 1999, the first edition of ISO 13407:1999, Human-centered design processes for interactive systems [4], was established to provide an international standard to interactive system development that focuses particularly on making systems usable. Its process embraces multi-disciplinary activity, which incorporates human factors and ergonomic knowledge and techniques, with the goal to support users and motivate them to learn. The benefits gained from this process can include increased productivity, enhanced quality of work, reduction in support and training costs, and improved user satisfaction [4].

The principles of human-centered design explained in the ISO 13407:1999, Human-centered design processes for interactive systems include: 1) the active involvement of users and a clear understanding of user and task requirements, 2) an appropriate allocation of function between users and technology, 3) the iteration of design solutions, 4) multi-disciplinary design.

Based on this standard, there are four human-centered design activities that should take place during a system development project, including: 1) to understand and specify the context of use, 2) to specify the user and organizational requirements, 3) to produce design solutions, 4) to evaluate designs against requirements. The human-centered process should be applied at the earliest stage of the project, and repeated iteratively throughout the process until the identified requirements are fulfilled [4].

User-centered approach encompasses many aspects including usability, accessibility, sustainability, suitability, credibility and usefulness of the product, system, service, or information provided to the intended users (see Figure 1). As a result, it needs a multi-disciplinary approach and teamwork to successfully complete the process (see Figure 2). This teamwork may vary from one project to another, but it mainly includes those in the fields of communication design, industrial design, user research, human factors, information development, marketing, project management, service and support, technology architecture, user interface design, and interaction design.

USABILITY PROCESS AND METHODS

While concerning with many issues, usability is currently the most recognized aspect of a user-centered design approach. Usability is defined as the measure of the degree to which users can perform a set of required tasks, as well as the quality of a user's experience when interacting with a product or system.

Usability practice, also called Usability Engineering, has currently become increasingly important, and has been incorporated into many product or system developments since businesses now recognize that high usability is one of the key factors helping to increase productivity, which finally leads to achieving maximum return, as well as retaining a competitive edge [1].

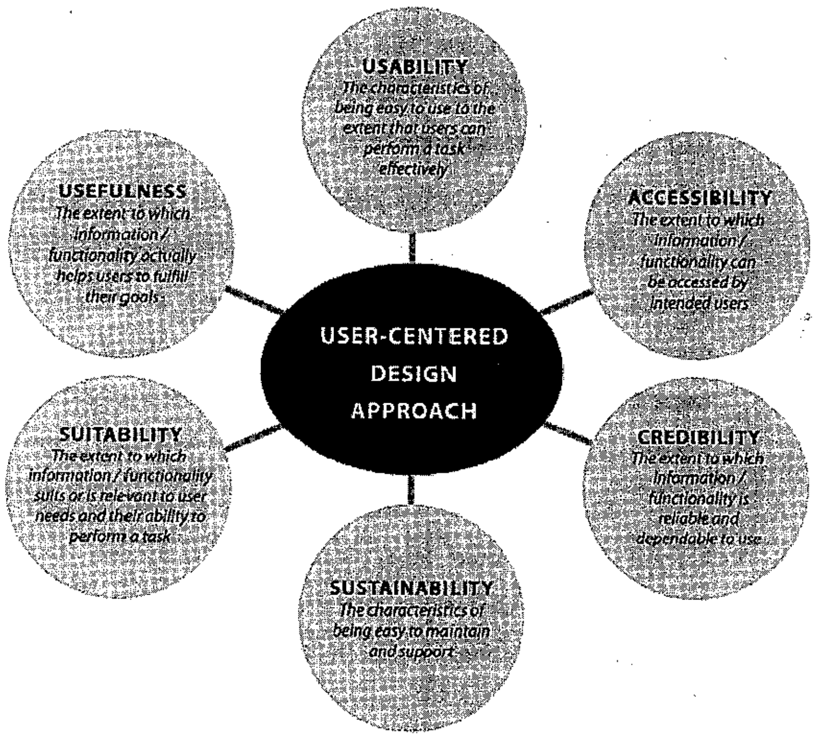
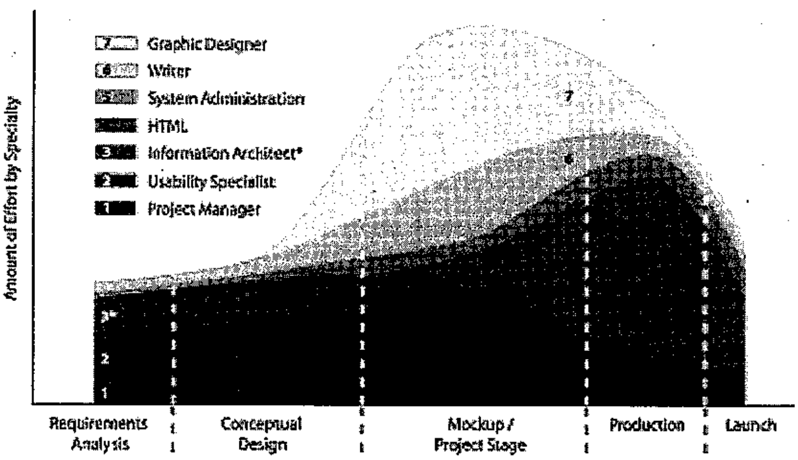


Figure 1. The multi-aspect of User-centered Design approach



*Indicates the new addition extended from the original diagram.

Figure 2. The Involvement of Multi-disciplinary Teamwork in a User-centered Project, (Extended from the original diagram "Staffing by Project Stage" depicted in the book "Usability for the Web: Designing Web Sites That Work" by Tom Brinck and others, 2002).

Usability research and its principles are grounded in and are the focus of Human-Computer Interaction (HCI) since it is particularly concerned with the relationship between products or systems and its intended users [8]. However, its practices are not limited to only user interface or computer software applications or web sites, but also include any user-operated device such as a household electronic product or mobile product. Usability of a product or system addresses several aspects: how well its functions fit user needs, how well the flow through of the product or system fits user tasks, and how well it responds to user expectations.

Usability depends on a number of factors that affect user performance and experience with the product or system, including ease and efficiency of use, ease of learning and remembering, error tolerance, functionally correct operation, and subjective satisfaction. It is particularly important that all the functions of the product or system perform correctly. Ease and efficiency of use is normally concerned with how fast users can use the product or system to accomplish a required task. Ease of learning and remembering addresses how quickly new users can learn to accurately perform a task, as well as how easy it is for users to remember and perform the same task the next time. Error tolerance addresses the degree to which the errors made by users are prevented, detected, and identified when they occur, and how easily they are corrected once they are identified. Eventually, it is also important that users feel satisfaction with the product or system [1].

Even though usability is rooted in HCI, some of its methods are heavily borrowed from Social Science such as ethnographic methods or field observation in particular; the process of usability practice is very much concerned with user input and feedback. As a result, gathering and analyzing user information, and performing user testing to evaluate design alternatives are common processes found in these practices.

A comprehensive user study is normally employed to collect and analyze information from the intended users. This information will be incorporated into the design consideration, as well as used in the evaluation process to assess usability of the product. The evaluation stage is particularly important to help detect any problems that may occur and compromise the usability of the product. As a result, the evaluation process should be conducted early and often throughout the product development process, both before and after the product or system is launched (see Figure 3).

The usability methods used for the gathering and analysis of user requirements in product development may include field observations, focus groups, user interviews and surveys, and competitive analysis. In the conceptual stage, these methods may include use cases, scenarios, and task analysis. These usability methods are considered generative methods that help designers to conceptualize and generate design solutions. In the mockup or prototype stage, common usability evaluation methods such as user testing and focus groups may be used to obtain user feedback.

In addition, quality assurance should be carried out through the process by continual and iterative user testing. To evaluate an implemented product or system, usability evaluation methods such as user testing and field observation should be performed to capture user interactions and identify potential problems.

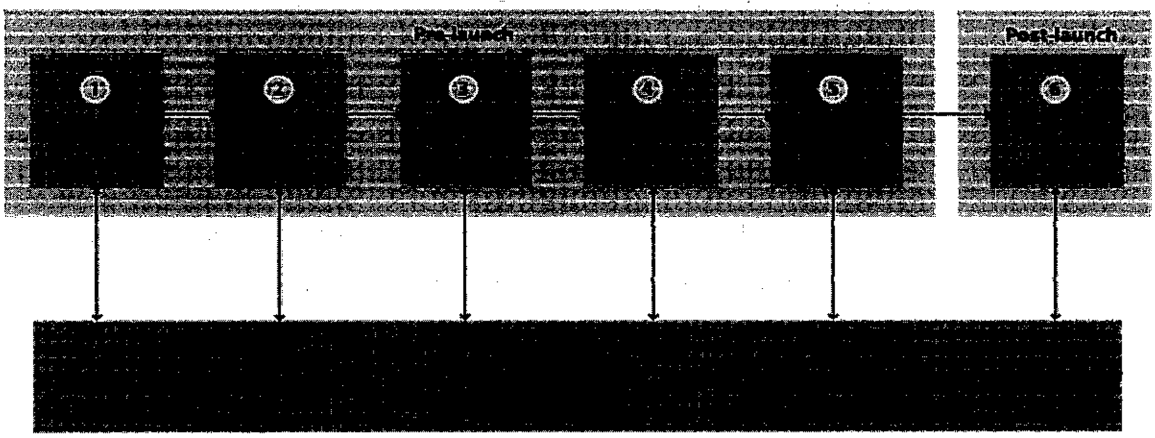


Figure 3. Usability Process (Modified from the original figure "Pervasive Usability Process" depicted in the book "Usability for the Web: Designing Web Sites That Work" by Tom Brinck and others, 2002)

Figure 4, the Taxonomy of Usability Methods, shows various types of usability methods used in different stages of product development process. This table is extended from the original table depicted in the ©2001 ACM paper "The State of the Art in Automation Usability Evaluation of User Interface" by Ivory and Hearst [5], which is primarily intended to specify which usability evaluation methods are automated or non-automated. However, the method list presented in this new table is not limited to only usability evaluation, but also extends to other types of usability methods (generative methods) as well. This new taxonomy is intended to identify which stage(s) of the design process use(s) which usability methods. The new table is divided into two main sections: 1) pre-launch stage which includes the processes of capturing user data and requirements, requirements analysis, idea generation, and usability testing, 2) post-launch stage which includes the processes of capturing and analyzing usage data (see Figure 4 and 5).

METHOD CLASS : METHOD TYPE	PRE-LAUNCH*					POST-LAUNCH*		Non-Automated Method	Automated Method
	Capture User Data / Requirements*	Requirements Analysis*	Idea Generation*	Prototype Testing / Pre-launch Testing*		Capture Actual Usage Data*	Analysis / Evaluation of Usage Data*		
				Capture Data	Analyze Data				
TESTING :									
THINKING-ALOUD PROTOCOL				x		x		x	
QUESTION ASKING PROTOCOL				x		x		x	
SHADOWING METHOD				x		x		x	
COACHING METHOD				x		x		x	
TEACHING METHOD				x		x		x	
CODISCOVERY LEARNING				x		x		x	
PERFORMANCE MEASUREMENT				x		x		x	x
LOGS FILE ANALYSIS					x		x		x
RETROSPECTIVE TESTING				x		x		x	
REMOTE TESTING				x		x			x
INSPECTION :									
GUIDELINE REVIEW					x		x	x	x
COGNITIVE WALKTHROUGH				x	x	x	x	x	x
PLURALISTIC WALKTHROUGH				x	x	x	x	x	
HEURISTIC WALKTHROUGH					x		x	x	
FEATURE INSPECTION					x		x	x	
CONSISTENCY INSPECTION					x		x	x	
STANDARDS INSPECTION					x		x	x	
INQUIRY :									
CONTEXTUAL INQUIRY	x					x		x	
FIELD OBSERVATION	x					x		x	
FOCUS GROUP	x			x		x		x	
INTERVIEWS	x			x		x		x	
SURVEYS	x					x		x	
QUESTIONNAIRES	x					x		x	x
SELF-REPORTING LOGS				x		x		x	
SCREEN SNAPSHOTS				x		x		x	
USER FEEDBACK				x		x		x	
ANALYSIS :									
GOMS ANALYSIS		x			x		x	x	x
UIDE ANALYSIS					x		x		x
COGNITIVE TASK ANALYSIS					x		x		x
TASK-ENVIRONMENT ANALYSIS					x			x	
KNOWLEDGE ANALYSIS		x						x	
DESIGN ANALYSIS		x			x			x	x
PROGRAMMABLE USER MODELS					x		x		x
COMPETITIVE ANALYSIS*	x	x						x	
INFORMATION ARCHITECTURE*			x					x	
SCENARIO-BUILDING*		x	x					x	
HIERARCHICAL TASK ANALYSIS*		x						x	
CARD SORTING*	x	x						x	
USER CASES*		x						x	
SIMULATION :									
INFORMATION PROC. MODELING					x		x		x
PETRI NET. MODELING					x		x		x
GENETIC ALGORITHM MODELING				x		x			x
INFORMATION SCENT MODELING				x		x			x

Figure 4. Taxonomy of Usability Methods (Modified from the original table "Automation Support for WIMP and Web UE Methods" depicted in the paper "The State of the Art in Automation Usability Evaluation of User Interfaces" by Melody Y. Ivory and Marti A. Hearst, ©2001 ACM Computing Surveys, Vol. 33, No. 4, pp. 470–516).

**Indicates the new additions of rows and columns of the table by author*

METHOD CLASS: METHOD TYPE	**DESCRIPTION**
TESTING:	
THINKING-ALOUD PROTOCOL	User talks during test
QUESTION-ASKING PROTOCOL	Tester asks user question
SHADOWING METHOD	Expert explains user actions to tester
COACHING METHOD	User can ask an expert questions
TEACHING METHOD	Expert user teaches novice user
CODISCOVERY LEARNING	Two users collaborate
PERFORMANCE MEASUREMENT	Tester records usage data during test
LOGS FILE ANALYSIS	Tester analyze usage data
RETROSPECTIVE TESTING	Tester reviews videotape with user
REMOTE TESTING	Tester and user are not co-located during test
INSPECTION:	
GUIDELINE REVIEW	Expert checks guideline conformance
COGNITIVE WALKTHROUGH	Expert simulates user's problem solving
PLURALISTIC WALKTHROUGH	Multiple people conduct cognitive walkthrough
HEURISTIC WALKTHROUGH	Expert identifies violations of heuristics
FEATURE INSPECTION	Expert evaluates product features
CONSISTENCY INSPECTION	Expert checks consistency across products
STANDARDS INSPECTION	Expert checks for standards compliance
INQUIRY:	
CONTEXTUAL INQUIRY	Interviewer questions users in their environment
FIELD OBSERVATION	Interviewer observes system use in user's environment
FOCUS GROUP	Multiple users participate in a discussion session
INTERVIEWS	One user participates in a discussion session
SURVEYS	Interviewer asks user specific questions
QUESTIONNAIRES	User provides answers to specific questions
SELF-REPORTING LOGS	User records User Interface operation
SCREEN SNAPSHOTS	User captures User Interface screens
USER FEEDBACK	User submits comments
ANALYSIS:	
GOMS ANALYSIS	Predict execution and learning time
UIDE ANALYSIS	Conduct GOMS analysis within a UIDE
COGNITIVE TASK ANALYSIS	Predict usability problems
TASK-ENVIRONMENT ANALYSIS	Assess mapping of user's goals into User Interface tasks
KNOWLEDGE ANALYSIS	Predict ability to learn
DESIGN ANALYSIS	Assess design complexity
PROGRAMMABLE USER MODELS	Write program that acts like a user
COMPETITIVE ANALYSIS*	Analyze User Interface in competitor's web site
INFORMATION ARCHITECTURE*	Build the structure, organization of web site, involve content analysis, planning, organization of pages
SCENARIO-BUILDING*	Describe specific individuals in specific circumstances
HIERARCHICAL TASK ANALYSIS*	Describe various aspects of how user works hierarchically
CARD SORTING*	Investigate how user forms concepts and categories of things
USER CASES*	Describe how user would typically interact with system
SIMULATION:	
INFORMATION PROC. MODELING	Mimic user interaction
PETRI NET. MODELING	Mimic user interaction from usage data
GENETIC ALGORITHM MODELING	Mimic novice user interaction
INFORMATION SCENT MODELING	Mimic web site navigation

Figure 5. Descriptions of Usability Methods (Extended from the original table "Descriptions of the WIMP and Web UE Method Types" depicted in the paper "The State of the Art in Automation Usability Evaluation of User Interfaces" by Melody Y. Ivory and Marti A. Hearst, ©2001 ACM Computing Surveys, Vol. 33, No. 4, pp. 470-516).

** Indicates the new additions by author*

Despite the fact that there are two categories of usability methods (generative and evaluative methods), most product developers are usually concerned with usability evaluation or usability testing (evaluative methods). Other usability methods (see Figures 4 and 5) that are used for gathering and analysis of information from actual users are less likely to be performed. There are only a few generative methods, such as scenario-building and task analysis, used for analyzing user data systematically in order to conceptualize forms, functions and meanings that are suitable to user needs. The usability testing methods, such as usability inspection, cognitive walkthrough, and user testing, applied in the iterative evaluation process, are intended to be used as analytical methods rather than generative ones. With the usability methods focused on analyzing user requirements, problems associated with generating design solutions are often disregarded or overlooked. Many products are conceptualized and prototyped without proper input information from actual users. This results in unexpected usability problems, which can be correctly identified only when usability testing is performed later in the process when much work has been invested.

CONCLUSION

Usability practice employs iterative design processes, including researching, designing, prototyping, and evaluating. The later usability problems are found, the longer the iterative design process, and the harder problems are to correct. These iterative cycles are essential, but also take time, effort, and budget as well. As a result, in order to streamline an iterative design process, usability problems need to be identified at an earlier stage, or even better, be prevented altogether. If product designers begin a project with proper input information from the actual targeted users, and employ methods that analyze this data systematically, potential usability problems can be decreased or prevented. Product designers need to foresee problems clearly at an early stage, and conceptualize and structure the product or system to minimize the usability problems even before usability testing takes place.

In conclusion, user-centered design is a design methodology essential to any product development process that seeks to improve the user's total experience when using or interacting with products or services. Its process strongly focuses on understanding users and incorporating an iterative design process based on their input and feedback throughout the development cycle.

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