SSURJET

Sir Syed University Research Journal of Engineering & Technology
2022, Vol. 12, No. 2,
https://doi.org/10.33317/ssurj.475

Devising a Usability Development Life Cycle (UDLC) Model for Enhancing Usability and User Experience in Interactive Applications

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Received April 01, 2022; Revised October 22, 2022; Accepted October 24, 2022

Abstract

To assess the quality, acceptability, and user experience of interactive applications, usability is one of the most integral quality attributes. However, a significant number of usability bugs and challenges are being experienced by the end users of interactive applications. Such usability bugs demand the need for a maturity model to target the unaddressed deficiencies in the area of usability. This research study aims to propose such a systematic and comprehensive maturity model, i.e., Usability Development Life Cycle (UDLC) model. To ensure easy and smooth implementation of the proposed model, a systematic and comprehensive set of guidelines is proposed along with the model. The model is validated for its competency by applying on a poor website and mobile application with weak usability. Execution of the proposed model on the targeted samples resulted in enhanced usability with improved user satisfaction.

Index Terms: *Interactive Applications, Usability, Usability Bugs, User Experience, User Satisfaction/Interface.*

I. INTRODUCTION

Usability is one of the most integral quality attributes to assess the quality, acceptability, and user experience of interactive applications. Therefore, for the past many years, software organizations are struggling to incorporate usability practices and usability-oriented engineering methods in the software development process [1]. Owing to the significance of usability, the research community has already made major contributions to proposing effective methodologies, techniques, models, and processes for usability concerns.

Authors proposed a usability model for software development [2], and [3]. A study has proposed a two-dimensional usability model (2-Dimensional Quality Meta-model) that creates a link between system properties and its intended user activities [4].

However, in existing usability practices, a large number of gaps and challenges are seen to be unmet and unaddressed. Such usability gaps and challenges serve as a motivation to conduct this research. Keeping in view the shortcomings in existing models and their consequences on the usability of the end product, we believe that unaddressed gaps can be addressed appropriately if somehow an exclusive usability maturity model is proposed. The objective of this study is to propose a systematic and comprehensive maturity model, i.e., Usability Development Life Cycle (UDLC) model. The proposed model would specifically target the unaddressed gaps and deficiencies in the area of usability. Moreover, to ensure the easy and smooth execution of the proposed model, a detailed and comprehensive set of guidelines is also proposed along with the model. The model is validated for its competency by applying on a poor website and mobile application with weak usability and bad user experience. Execution of the proposed model on the targeted samples resulted in enhanced usability with improved user satisfaction.

The rest of the paper that follows is organized into eight sections. Section II discusses the research methodology. Section III makes a review and analysis of existing usability practices. Section IV addresses the usability gaps, and proposes a usability maturity model, i.e., the UDLC model.

However, to make the execution of the proposed model easy and smooth, a systematic set of guidelines are presented in Section V. Section VI attempts to evaluate the proposed model. The discussion of the study is covered in Section VII. Finally, the conclusion and the directions for future advancements are given in Section VIII.

II. RESEARCH METHODOLOGY

To address the identified usability gaps, this study proposes a systematic and comprehensive maturity model as shown in figure IV. Moreover, to ensure the easy and smooth execution of the proposed model, a detailed and comprehensive set of guidelines is proposed in Section V.

For evaluating the proposed model on targeted websites an online usability assessment survey is designed and conducted using the ‘Online Google Forms’ service. The designed survey is comprised of 15 questions. Each

question in the survey form is provided with 3 options. The chosen questions for the survey (as shown in table II) are ensured to be capable enough to assess the usability of web-oriented interfaces by targeting important usability concerns. Moreover, to evaluate the targeted mobile application, it is explored, used, and assessed against usability principles. The exploration resulted in the identification of a number of existing usability flaws and bugs as reported in Section VI-C. The identified usability flaws are resolved by the execution of the model proposed by this research study. Execution of the proposed model on the targeted samples resulted in enhanced usability with maximum user satisfaction.

III. RELATED WORK

In order to identify the unaddressed gaps existing in current usability, this section performs the review and analysis of existing approaches. Author Kanza et al., have proposed a framework that maps attributes of usability requirements to the linguistic assessment of users by implementing fuzzy logic [5]. Ismail et al., have targeted upon identifying and finding out the usability issues being faced by mobile application users [6] Harrison et al., in a study have put forward a literature review discussing the usability of mobile applications and how and to what extent usability is important for mobile applications [7]. Shahida et al., have put forward an effort to identify and explore the state of the art for detecting and reporting the usability flaws and defects in usability engineering and software engineering literature [8].

Haaksma et al., have made an attempt to mark the relationship between two quality contributors to interactive applications: Usability and User Experience (UX) [9]. Raza et al., have tried to establish a relationship between usability bugs in open-source software (OSS) and online forums for public users by presenting a research model and hypothesis [10]. In a study, a questionnaire approach has been used to figure out the quality factors of mobile learning systems [11]. Pucillo et al., have proposed a framework to create a link between the needs of users, their experiences, and affordances [12]. Bargas-Avila et al., have made an effort to investigate the research conducted on user experience [13]. Michalco et al., have reviewed theories that describe how user experience is ruined because of user expectations [14]. A history of usability is discussed in a study [15]. Hertzum et al., have defined the broadly discussed usability in terms of its constructs and how is it different from user experience [16].

Strate et al., in a study, have tried to present a literature review of the research that has already been conducted on software defects [17]. Breu et al., have emphasized how bug reporting tools and mechanisms can build collaboration between users and developers and how much bug reports are important for the detection and fixation of bugs and defects [18]. In a study, the research community has tried to investigate the usability issues encountered by the users of website interactive applications [19]. Studies have performed the evaluation for a hotel website by analyzing the viewpoints of the customers and also through content analysis [20].

Faisal et al., in a study, have made an effort to evaluate the preferences of the user attributes of web design to determine loyalty, satisfaction, and trust for the users [21]. The research community proposed the five attributes of web design, i.e., typography, color, content quality, interactivity, and navigation. The study provides an interface that describes negative vibrotactile feedback [22]. The research community worked on improving the online interactive study process [23]. Miraj et al., in their study, have made an effort on determining the most user-friendly location for displaying the error messages in web form and applications [24]. Macaulay has attempted to address issues of user-centric design and its obstacles. Also, it provides techniques for the improvement of scientific software usability [25]. Fukuzumi et al., have made an attempt to figure out and propose the problems that occur when a user-centered design process is applied in software development to ensure the usability of the software [26]. The study has made effort to make the discussion that can help improve the design of cloud applications specifically health-based applications [27]. Whereas, Lee and S Koubek have tried to evaluate to what extent usability and the design of the websites can impact the overall performance of the users [28]. Ganguly et al., have claimed that the absence of trust in online shopping is the main reason for the deviation of customers from shopping online [29]. A study has also targeted web applications that how aesthetics of the interface, specifically of the home page, can improve user satisfaction, usability, and user experience [30]. Similarly, the effect of the visual design of the web application on the increased or decreased rate of customers is further discussed in a study [31].

Laura et al., have proposed a number of guidelines on usability improvement so that software engineers can develop applications with the least usability flaws and more user satisfaction [32]. A study has made an effort to evaluate the interfaces of Inductive Intra-Oral Tongue Computer Interface (ITCI) facilitated systems considering the intended usage [33]. Lascu et al. in a study have contributed towards making the design guidelines to be used in design space [34]. Partala et al., have made an attempt to study the structure of user experiences that are satisfactory and others that are unsatisfactory [35]. Sfetsos et al., have attempted to extend the agile development framework toward a user-centered design process [36]. A study has discussed API in terms of usability. Usability practices that are applied in the development process of API are also discussed. The component-based approach is linked to API usability [37].

Sang et al., have presented a prototype that can help users take the advantage of multiple touch interaction styles in mobile and then can improve the visual intent in an easier and more convenient style [38]. A survey is conducted to take the concept of user experience towards maturity [39]. A Study has proposed a sub-system for human-computer interaction that would overcome the existing issues of the current human-computer interaction system but would offer the users with standard friendly interface [40]. Another study has made an attempt to understand the attitude of learners toward e-learning [41]. The research community has tried to distinguish between usability and overall quality user experience [42]. A study specifically addresses the

usability of Digital rights management sharing applications. Moreover, it has also discussed how expertise affects perceived usability [43].

Kumar et al., have made an effort to analyze the usability of an educational ERP system by using a fuzzy model that uses metrics [44]. Lung has proposed a method for measuring the usability of cloud services [45]. Aminah et al., have designed a model for the quality assessment of software with Service Oriented Architecture (SOA) [46]. Bessghaier et al., have performed the usability evaluation of those mobile applications which are hybrid in nature [47]. A study has made a survey to discuss how defect reporting can help to fix and resolve bugs [48]. While in another study after exploring a number of usability defect reports tried to examine the mismatch and difference between what software practitioners provided during reporting and what they actually mentioned in defect reports [49].

In one study a discussion was made to relate the term usability for mobile applications and also presented state of art for evaluation of mobile applications [50]. Lewis have made the discussions to learn what are the controversies in the area of usability [51]. Law et al., in their study, have tried to investigate the measurable nature of user experience [52].

In a study, an attempt was made to evaluate the user experience of mobile applications by utilizing both the approaches; questionnaires and eye tracking approach [53]. While Wu et al., have attempted to identify the antecedents of customer satisfaction [54]. A study has determined the Innovation Center Innovation System's performance based on user experience [55].

Soure et al., have proposed a collaborative visual analytics tool, CoUX, to facilitate UX evaluators collectively reviewing think-aloud usability test videos of digital interfaces to overcome the challenges that arise when multiple UX professionals need to collaborate to reduce bias and errors [56].

Authors in a study investigated the ML usability challenges that are present in the domain of child welfare screening through a series of collaborations with child welfare screeners [57].

A. Findings

Due to the significance of usability attributes in determining the acceptance and rejection of the software by its intended users, a large number of studies and efforts are already done in the area of usability as mentioned in Section III. However,analysis of existing usability practices disclosed limitations and gaps as shown in table I.

Identified gaps are structured and categorized to a broader context on the basis of their nature of relevance and closeness.

The usability gaps reported in table I are existing at different stages of an SDLC. To illustrate the existence of identified gaps in the current software production process, figure I maps the identified usability gaps in various stages of SDLC.

To cope with these gaps, we present recommendations against each stage to be incorporated into the existing software production cycle as listed in figure III.

Table I: Categorized Usability Gaps

S. No	Stages of an SDLC	Categorized Usability Gaps
1	Determination of Usability Objects.	Poor Elicitation Mechanism for Understanding Usability Requirements Effectively
		More Bounce rate of users
		Absence of Task Analysis Mechanism
		Poor Determinations of Usability expectations of the intended users and making them accessible
2	Usability Measurement	Lack of efficient and effective scale for Usability Measurement
3	Usability Design	Unapplied Design Process
		Lack of Rational Judgmental model for creating design
4	Usability Defect Reporting	Poor Usability defect identification, analysis, and Reporting mechanisms
		Unaddressed usability defect reporting challenges
		Poor Usability Defect Report Formats
5	Usability Testing Mechanism	A week and Poor Usability Testing Mechanisms
6	Usability Documents	Unavailability of Usability Manuals/Documents and Guidelines
7	Online User Services	Improving Post Delivery services

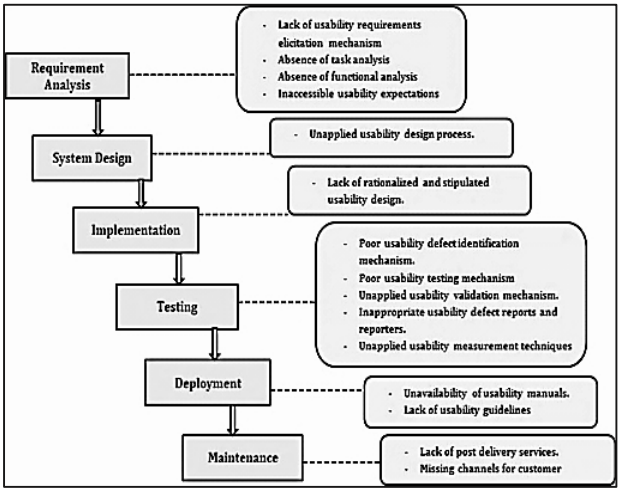


Figure I: Usability Gaps in Existing Software Process

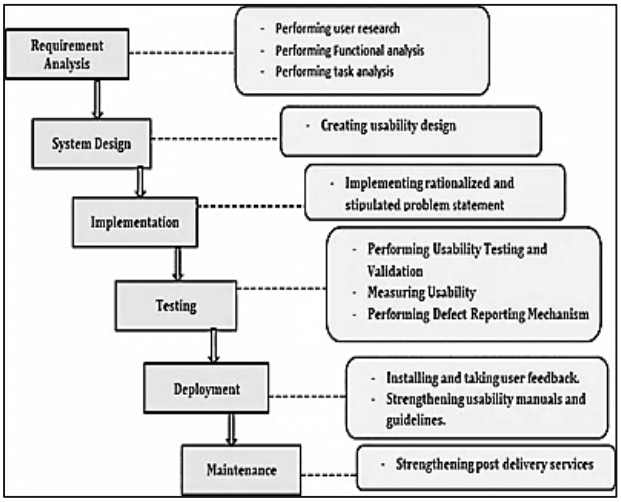


Figure II: Recommendations for Existing Usability Gaps

To overcome the identified usability gaps, there is a need for a complete and systematic usability model. We intend to put forward such a model in the following section. As this model is exclusively responsible to mature the usability attribute in the whole process of software production and would run along with SDLC, therefore it is assigned the name Usability Development Life Cycle (UDLC) model. The proposed model aims toaddress

the usability gaps reported in figure I by puttingthe recommendations of figure II into practice.

IV. PROPOSED MODEL: USABILITY DEVELOPMENT LIFE CYCLE (UDLC) MODEL

To address the usability gaps and limitations reported in the previous section, this section attempts to propose a usability maturity model. As the reported usability gaps in table I are mainly structured in seven main categories, therefore to address each category, the proposed model is structured into seven levels as shown in figure III.

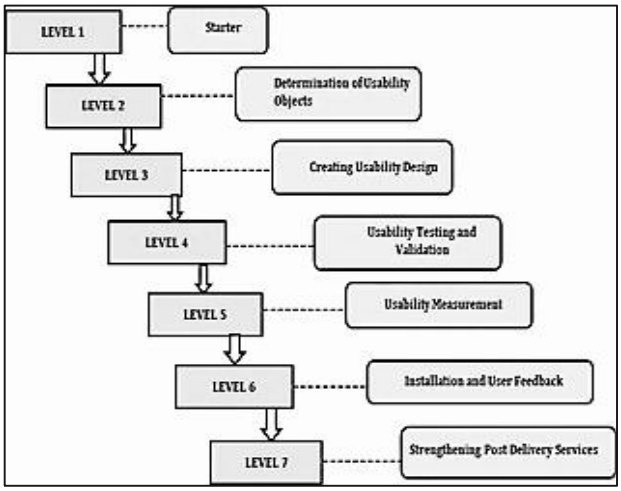


Figure III: Usability Development Life Cycle (UDLC) Model

However, each level is further comprised of certain key process areas as shown in figure IV.

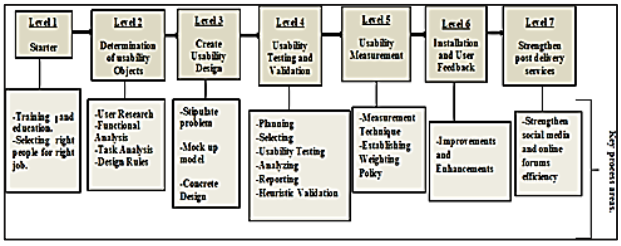


Figure IV: Proposed UDLC Model with KPAs

A. Level 1: Starter

This level would be an introductory and preliminary phase that the firm should follow. At this level significance of the UDLC model would be introduced to the organization which would enable the organization to select and recruit suitable persons for various jobs that would be required for implementing the UDLC model.

B. Level 2: Determination of Usability Objects

Determination of usability objects is the first step of the UDLC model. This step intends to identify who are the intended targeted users of your application. It is concerned with who would be the actual users that would be availing and using the application or service which would be the end product of this process. This level would help identify the needs, wants, and expectations of the users, from the application. Apart from identifying users, it would help identify the purpose of the new application and also the novelty that users demand from this new application. Moreover, the context, success criteria of usability, and utility would also be identified and reported at this level. However, to address all these concerns, this level would perform functional analysis, task analysis, users' research, and general design rules to determine the actual and concrete usability objects of the end product.

C. Level 3: Create Usability Design

After the requirements analysis and determination of usability objects, the next level to be followed by the UDLC model is Usability Design. This level of UDLC focuses on UCD. At this level, designer will first focus on rationalization and stipulation of the problem statement for which the model incorporates a separate sub-model, i.e., the Rational Judgmental Design Model at this level. This sub-model would help the designers to understand the feelings, problems, and expectations of the user by putting themselves into the shoe of the user before proposing the problem statement. By using this approach, the declared problem statement will be empathetic and it would help the designers to produce more user-centered ideas, and ultimately the concrete design and the prototype will also be user-centered. The sub-model would be sequential but non-linear and flexible in nature. It would help different members of the design team to work on different stages simultaneously.

D. Level 4: Usability Testing and Validation

Once the application is done and ready for delivery to the end users. It is of worth important to test the application before releasing it to users. The proposed model emphasizes on introducing usability testing at a separate level. This level of usability testing would specifically address and examine the usability attribute of the product. Usability testing would help to discover usability defects, bugs, and issues in the product that can later be resolved and fixed before release. It would help to expose the defects that cause hindrances in the ease of use of the application for the user. Moreover, it would help to determine whether the application fulfills the usability objects that were identified at an initial level of the usability process.

Moreover, this level would also perform heuristic validation. The ultimate goal of this prerelease heuristic validation is to ensure the desirability of the user in the product. The condition for applying this testing validation mechanism is to establish and decide some novel heuristics according to the nature of the product you are going to validate. It is important to select the right set of heuristics at this level as if not, it may overlook a certain amount of usability issues. The design that is under scrutiny should be validated against application-specific heuristics.

E. Level 5: Usability Measurement

Measuring usability has always been challenging for organizations which ultimately causes hurdles in improving usability and attaining user satisfaction. Lack of usability measurement techniques and scales leads to emerging usability errors, defects, and bugs and hence spoils the user experience. Keeping in view these facts, the model incorporates a specific level under the subject of usability measurement and provides a technique to measure usability. The model attempts to understand the perceived usability of the application for the user by performing a

usability measurement mechanism. Moreover, an easy and cost-effective technique for usability measurement is proposed in the model guidelines.

F. Level 6: Installation and User Feedback

After the software is completed and the formalities of usability testing and validation are complete, the next level would be installing or deploying it for the user and getting their feedback. The feedback taken from the users can be further worked on to fill in any missing gaps or issues reported by the user. After deploying, it would be a good practice to keep on tracking your users and collecting usability data and usability defects. These usability defects will be addressed to minimize usability bugs and avail maximum user satisfaction.

G. Level 7: Strengthening Post-Delivery Services

As an end product, some software or application is delivered and published at the end. During publication, it costs money to have a website where designers can host the documentation and have a way by which developers and designers can intersect with users. Users come up with bugs and suggestions and they implement them and that's how software keeps increasing. At this level, a user would be given a platform where designers can host their end product and can have such, interesting for the users. Users can report their queries and designers can help them through this channel. This level would also look forward to improving the efficiency of all those social media and forum sites that can help users in copping up with usability-related issues in some way. It will surely enhance usability. This section proposed a systematic usability maturity model to address the existing gaps and challenges. However, to make the execution of the proposed model easy and smooth, it is important to provide a systematic set of guidelines for each level. We attempt to provide a such set of guidelines in the following section.

V. GUIDELINES FOR UDLC MODEL

In the previous section, this study proposed a usability maturity model, i.e., UDLC. However, to make UDLC easy to implement and execute, this section attempts to propose a comprehensive and systematic set of guidelines against each maturity level in the following sub-sections.

A. Level 1: Starter

This level would be an introductory and preliminary phase that the firm will follow. At this level significance of the UDLC model would be introduced to the organization which would enable the organization to select and recruit suitable persons for various jobs required for implementing the proposed model. The organization can conduct scheduled workshops at this level to introduce the importance of usability, the need for a usability maturity model, the need for the UDLC model, and usability tools and techniques. The tools and platforms will also be selected at this level. Moreover, the organization can create some strategy for recruiting the right people for the execution of this model.

B. Level 2: Determination of Usability Objects

In order to determine the concrete usability objects of users, it is significant to conduct the first stage of requirement analysis up to a remarkable level. In order to determine usability objects, this level would conduct functional analysis, task analysis, users' research, and general design rules. Figure V indicates the main and key process areas of level 2.

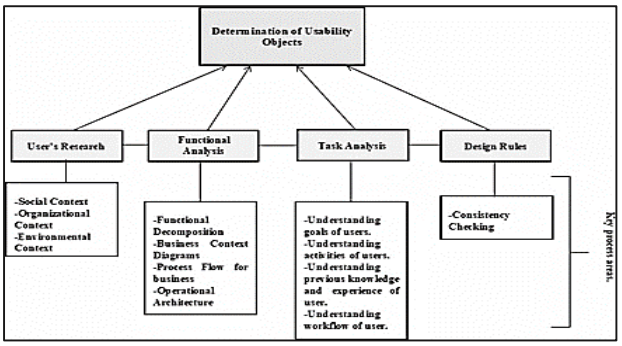


Figure V: Determination of Usability Objects

1) Users Research:

This level focuses on studying the users in terms of their personal characteristics and how do they vary when they are working in personnel. While in order to understand the users it is important to understand the contexts of the users from various perspectives such as social context, organizational context, and environmental context.

2) Functional Analysis:

Functional analysis will describe how the system functions primarily to show the user that it meets usability requirements. When all of the scenarios are gathered for the new product, requirement elicitation is complete, and all of the assumptions that are to be kept in mind to design the new application are clear; before converting them to concrete requirements and formalizing them to their detailed definition, the proposed model considers is it important to move a step back and perform a functional analysis at a high level. The purpose of conducting this functional analysis at this level is to ensure that all area of the business context is covered and none of the functionalities are missed. However, to perform functional analysis certain techniques can be put into practice, i.e., Functional Decomposition, Business Context Diagrams, Process Flow for Business, and Operational Architecture.

3) Task Analysis:

Task analysis is an important step to identify the users in terms of their task, i.e., how do they accomplish their task? How do their tasks help them to achieve their goals and objectives? It also helps the analyst to identify those tasks that are supposed to be supported by the application or product from the user's point of view. It will help to identify the scope of the product at an earlier stage. Figure VI shows the key areas and outputs of task analysis.

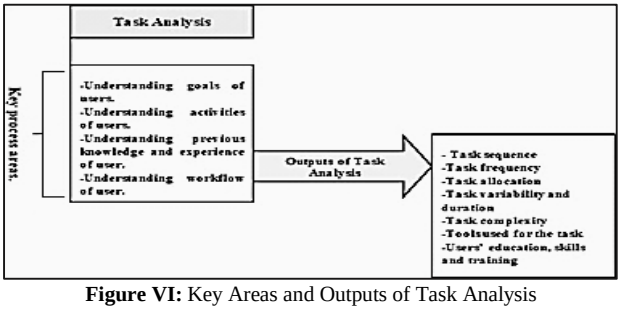


Figure VI: Key Areas and Outputs of Task Analysis

4) Design Rules:

Once the task and functional analysis are complete, it would be important to coordinate them as a whole at this stage and check the consistency among them to avoid conflicts and contradictions at a later stage.

C. Level 3: Creating Usability Design

Once the requirements are analyzed and usability objects are determined, the next phase to be followed is Usability Design. Model guidelines focus on User-Centered Design (UCD).

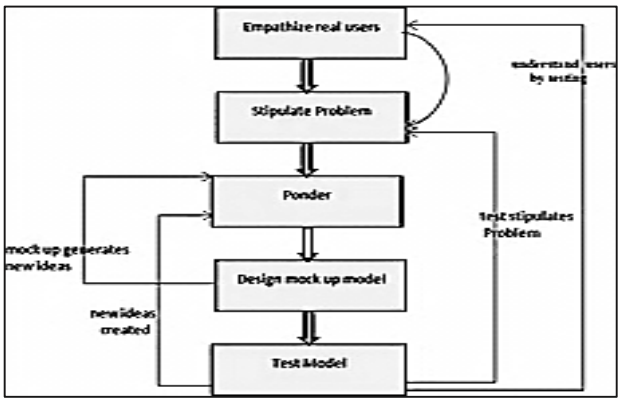


Figure VII: Rational Judgmental Design Model

The proposed model considers it important to incorporate a sub-model for usability design. By using this sub-model, the declared problem statement will be empathetic and it would help the designers to produce more user-centered ideas. Such a model is proposed, i.e., Rational Judgmental Design Model. This design model is sequential but non-linear and flexible in nature. Different members of the design team can work on different stages simultaneously. Designers standing at one stage can backtrack to some previous stage, depending on the results it produces. The stages of this non-linear design model are shown in figure VII.

1) Empathize Real Users:

The first step of this rational judgmental model is to gain a deep understanding of the problem that you are trying to solve. For designers, in order to understand the problem from the core, it is important to understand the actual users in depth by putting themselves in the shoe of the user. It will ensure that the design would be user-centric rather than designer centric. In order to perform this job, designers would consult professional experts and they can understand the area under concern by engaging, empathizing, and observing people to know their motivations and experiences. Information gathered during this phase would help to stipulate the problem of the specific product you are working on. An empathy matrix can be used for this purpose.

2) Stipulate Problem:

In this step, designers will utilize all the information gathered during empathize stage and will arrange and analyze that to stipulate the actual problem that needs to be solved. Again it is to be kept in notice that the stipulated problem should be user-centric. This stage will also help the designers to collect novel ideas to create features, elements, and functions that will help to solve the problem and would assist users to complete their goals with ease.

3) Ponder:

Once designers are done with understanding the users, their needs, wants, expectations, and demands, and are well aware of the stipulated problem that is to be solved; next, designers can ponder and think aloud to generate novel ideas that can help to provide an efficient and user satisfactory solution.

4) Design Mock-Up Model:

At this stage, the designers will produce a down version or a mock-up model of the product by adding certain features and functionalities to it. The purpose of this step is to identify one of the best solutions proposed in the previous stage.

5) Test Model:

At this stage, the designers test the end product that is produced by using the best solution. This stage may help to generate more ideas for proposing the solution. It can even help to stipulate the problem in a more precise and better way or can provide some alternative way to look at the problem.

D. Level 4: Usability Testing and Validation

The next phase to be followed after the design of the product is usability testing. This phase is incorporated to help users and the representatives operate and use their products, observe their actions and operations and also entertain their queries and questions.

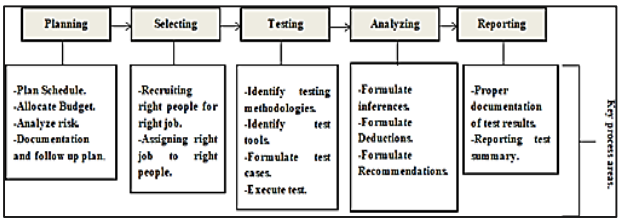


Figure VIII: Usability Testing Model with Key Areas

This usability testing would be from an external perspective that how do the users interact with the end product.

Keeping in view the significance of Usability Testing, our model guidelines put forward a separate sub-model specifically for Usability Testing as shown in figure VIII above.

The levels of this sub-model are: Planning, selecting, testing, analyzing, and reporting. The mechanism of Usability Testing is mentioned as follows:

1) The planning phase would comprise of determining the objectives and goals that would be achieved by conducting usability tests.
2) In Selecting phase testers, reporters, and tools planned in the planning phase are selected according to the desired capabilities.
3) During the testing phase conduction of usability tests are made and executions are made in the testing environment.
4) During Analyzing phase, the results obtained by executing usability tests are analyzed.

Inferences and meaningful deductions are made from the results. These inferences are then used for providing recommendations that would help to enhance the usability of the application.

5) The last phase is reporting where usability test reports are created and then circulated among all important stakeholders.

E. Level 5: Usability Measurement

In order to enhance the usability of the applications, it is important to measure the usability in some quantitative way. When we have some way to measure the number of errors or bugs in software, the quality of the software can be measured by some reasonable index.

There is a need to apply some well-defined weighting policy on this usability attribute to develop a scheme for usability measurement. Design principles are highly valuable in terms of usability and quality of the product. This proposed approach is based on the utilization of design principles. The purpose of this approach is to put forward measurable indexes by considering usability dimensions. Therefore, it would be highly useful if user concerns related to design are also somehow utilized in this weight calculation scheme. Hence, by using these three components, i.e., usability dimensions or characteristics, user design concerns, and the weighting policy, an attempt is made to put forward an enhanced usability measurement technique for interactive applications.

The UCW approach (Working) can be explained as follows:

The approach is named 'UCW', on the basis of its components, i.e.: usability dimensions, concerns of the user about design, and weighting policy.

UCW's approach starts by creating and providing a cellular table. The horizontal cells (rows) of the table contain the concerns of the user about design principles by adding them on the basis of their priority while the vertical cells of the table contain usability dimensions. The entries in cells are generated on the basis that how the users assign a numerical value to design concerns on the basis of usability characteristics or sub-characteristics. Horizontal cells are preferred to be static (fixed) as they contain user concerns while vertical cells of usability dimensions can be made dynamic. The number of horizontal and vertical cells will be finite and easily countable. The values assigned to the cell will be numerical. The total value for a particular usability

dimension can be obtained by adding all the values of that particular column. Likewise, the total value of design concern can be obtained by adding the values of the row cells.

The next step is to decide on some weighting policy for assigning the values. This weighting policy is subjective and can be modified as per the scenario and ease of the users. The grade in the table is calculated by adding the subtotal grades. Subtotal grades are obtained by assigning the values to the cells according to the weighting policy. As individual grades (values) of the cell are numerical entries so the aggregate would also be numerical.

As users assign the values according to some format that is convenient for them. But even if they are asked to assign values between 0 to 100, it would highly increase the computational complexity when they are dealt with at the system end. So, the final step would be the normalization of the values assigned by the user and the calculation of the final value as a normalized value. In this way, the sub-grades will be between the range of 0-1, and the overall grade will be in the range of 0-100.

F. Level 6: Installation and User Feedback

After the software is completed and formalities of usability testing are performed successfully, it is to be installed for the user. When it is installed, it would be a good practice to keep on tracking your users and collecting usability data and usability defects. These usability defects will be addressed to minimize usability bugs and avail user satisfaction.

This phase of user feedback should comprise of following three major steps:

1) Welcoming user suggestions,
2) Generating new requirements, and
3) Performing continuous improvements.

Figure IX shows the process for user feedback.

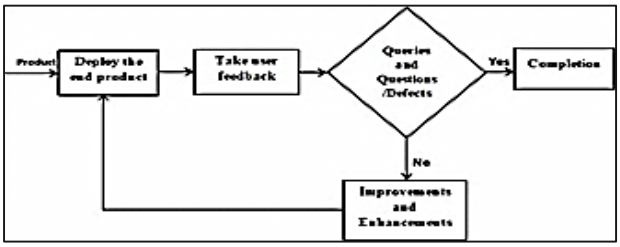


Figure IX: User Feedback Process

G. Level 7: Strengthening Post-Delivery Services

Post-delivery services can be strengthened by improving social media and online forums' efficiency to assist customers. As an open-source community, they prepare some software and publish it. During publication, it costs money to have a website where they can host the documentation and have a way by which developers can intersect with users. Users come up with bugs and suggestions and they implement them and that's how software keeps increasing. An example would the 'Word-Press'. If such a platform is offered where not only a website is published where they can host their software but also have interaction with users, it will surely increase usability. This model focuses on a platform with not only a website to host the software but also a forum-based platform. It will cause ease for users and will also eliminate some pain for designers. Moreover, at this level, all the social sources, web sources and guidelines, and documents that can assist the end users and can contribute towards improved usability will be updated and enriched with all necessary and relevant information.

VI. EVALUATION OF THE PROPOSED MODEL

In order to assess the quality and efficacy of the proposed model, this section attempts to evaluate the model along with its guidelines. To perform evaluation, we have targeted two types of interactive interfaces, i.e., websites and interactive mobile applications.

A. Evaluation on Websites

This section discusses the evaluation of the proposed model on websites. It elaborates on the adopted evaluation methodology, criteria for selection of sample websites,

usability assessment of sample websites, redesigning the selected website, and the comparison between the old and improved version of the selected website.

1) Evaluation Methodology:

We have accessed the google repository (using the source link https://www.rankingbyseo.com/blog/bad-websites/) reporting a list of poor websites with poor usability and bad user experiences. From the reported list, 4 random sample websites are selected. In order to receive authentic results of the sample websites regarding their usability, an online usability assessment survey is designed using the online google forms service. The designed survey is comprised of 15 questions.

Each question in the survey form is provided with 3 options: Yes, No, and May be (Yes: agree; No: disagree and Maybe: partially agree). The chosen questions for the survey are ensured to be capable enough to assess the usability of web-oriented interfaces by targeting important usability concerns that must be considered by users of the web interface. The selected sample interfaces along with the designed usability assessment survey are provided to the users; each sample website is to 3 different users. The targeted users are academic students. As each sample website is assessed by 3 different users; 3 responses are received. The collective results of all responses for each sample are fetched using csv (comma-separated value) file of the designed survey. The result summary received in the csv file is further transferred to an excel spreadsheet, hence making the results more understandable and easy to display. The sample websites along with the analysis results of their assessment are reported in Section VI-A.2. The results and analysis of these usability assessments for each sample disclosed the usability bugs and errors that caused the users to feel frustrated and annoyed by using them. Moreover, it disclosed the significant usability attributes that should be targeted when web interfaces are designed.

After collecting the results of the usability assessment and reporting the significant usability attributes to be emphasized, we have selected sample-4 for redesigning by applying our proposed model along with its guidelines. We have specifically targeted the usability bugs that were neglected in selected samples. Sample-4, i.e., the website of an art school is redesigned by following our proposed model guidelines. The new version (redesigned version) along with the same usability assessment survey is made available to the same users for usability assessment. The same mechanism is followed for generating results and analysis. A comparison is made for user assessments of both the old and new versions of the interface. The results showed that the new version is more usable and satisfactory than the old version. Hence, this improved usability validated the efficacy of the proposed model.

2) Sample Interfaces with Results of Usability Assessment:

This section reports the usability assessment of sample websites:

- Sample-1, (http://best-electronics-ca.com/) is comprised of a website for electronic appliances. The site is named as 'Best Electronics'. However, the site is lacking in terms of usability.
- Sample-2, http://www.arngren.net/ is an online selling website. The layout and overall design of the site seem to be too much congested and poor in terms of user satisfaction.
- Sample-3, https://www.lingscars.com/ is a website for cars for leases. However, the overall design and layout of the site hardly make the actual purpose of the website clear.
- Sample-4, https://www.art.yale.edu/ is a website for an arts university. Being the website for Arts University, it makes an impression that it would be richer in terms of aesthetics, design, layout, navigation, adaptability, and overall usability. However, it keeps the senses of users assaulted as it contains a number of usability flaws.

3) Applying UDLC Model to Redesign Sample-4:

Sample-4 which is a website of an 'Arts School' is selected for improvement purposes to evaluate the quality and efficacy of the proposed model. Table II shows the analysis of the usability assessment for sample-4. In order to address the usability gaps in sample-4, we intend to redesign the interface of the selected sample by applying our proposed model, i.e., UDLC. Level-wise implementation is provided in the following sub-sections.

Table II: Usability Assessment of Sample-4

Usability Assessment Results for Sample 4							
S. No.	**Questions**	**User Responses**			**Percentage Wise Response**		
		User 1	**User 2**	**User 3**	**Yes %**	**No %**	**May be %**
1.	Are you satisfied with the readability of the Interface?	No	No	No	0	100	0
2.	Is information visualization satisfactory?	No	No	No	0	100	0
3.	Are color aesthetics appealing enough?	No	No	No	0	100	0
4.	Is enough user control provided?	No	No	No	0	100	0
5.	Is the navigation user-friendly?	No	No	No	0	100	0
6.	Are provided links useful?	No	No	No	0	100	0
7.	Is interface design intuitive?	No	No	No	0	100	0
8.	Is the orientation and size of objects appropriate?	No	No	No	0	100	0
9.	Is this website free from complexity and tediousness?	No	No	No	0	100	0
10.	Is this website free from frustration and animations?	No	No	No	0	100	0
11.	Are clickable areas positioned appropriately?	No	No	No	0	100	0
12.	Is this site causing user fatigue?	No	No	No	3.33	66.7	0
13.	Are the popup menus disturbing for the user?	No	No	No	66.7	3.33	0
14.	Are you satisfied with labeling?	No	No	No	0	100	0
15.	Is provided content appropriate?	No	No	No	0	100	0

- Level 1: Starter

At this level, objectives are set and the goal is defined. The objective in the current scenario is to redesign the new version of selected sample-4 to fix the usability issues existing in the old version. Moreover, a tool used for redesigning is decided, i.e., WordPress.

- Level 2: Determination of Usability Objects

At this level usability objects (concrete requirements) are determined. As the results of the usability assessment for the old version have already disclosed the missing usability attributes in the existing old interface, we intend to take those usability concerns as our usability objects. We aim to redesign the improved version of the website in such a way that a maximum of the usability bugs is fixed. The identified users of this new version are the same as that of the old, i.e., academic users.

- Level 3: Creating Usability Design

Once usability requirements and the intended users are clearly identified and reported, the interface of the selected sample is rebuilt using the tool specified in level 1. The usability objects determined in level 2 and the intended audience are continuously considered while the new interface is being redesigned.

- Level 4: Usability Testing and Validation

In order to test and validate the improved version, the new interface design is made available to the same set of users as specified for the old version. The users are asked to perform a usability assessment of the new version using the same usability assessment survey as used for the old version. User responses and results were analyzed using the same mechanism as used for an older version. Figure X (a)-(g), shows the new interface.

- Level 5: Usability Measurement

From the performed analysis, it is clear the improved version has fixed the usability concerns existing in the old version to a maximum extent. Intended users are satisfied and the interface is building a good user experience. User concerns are used to assess and measure usability by using a usability assessment survey.

- Level 6: Installation and User Feedback

The new version is assigned to the users.

- Level 7: Strengthening Post-Delivery Services

An option is set in the interface of the new version (as shown in figure X (d) and figure X (e) that users can use to interact and report their queries.

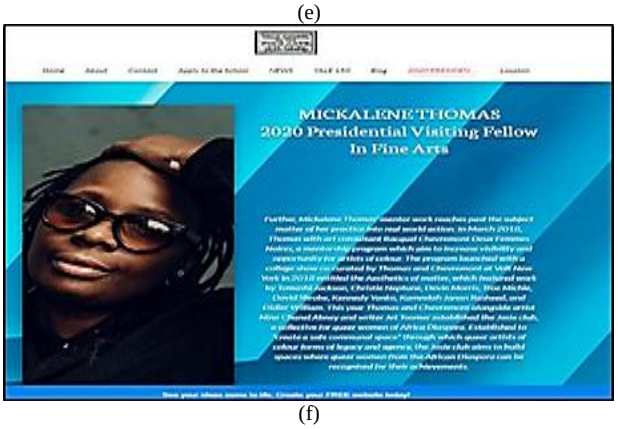
(a)

(b)

(c)

(d)

(e)



(f)

(g)

Figure X: (a)-(g); The New Interface Design for the Same Set of Users as Specified for the Old Version Based on User Responses followed by an Analysis of Results.

4) Comparison of Old and New-Version:

The result and analysis of the response for a new version are shown in table III.

Table III: Usability Assessment New Version

Usability Assessment Results for New Version							
S. No.	Questions	User Responses			Percentage Wise Response		
		User 1	User 2	User 3	Yes %	No %	May be %
1.	Are you satisfied with the readability of the Interface?	Yes	Yes	Yes	100	0	0
2.	Is information visualization satisfactory?	Yes	Yes	Yes	100	0	0
3.	Are color aesthetics appealing enough?	Yes	Yes	Yes	100	0	0
4.	Is enough user control provided?	May be	Yes	May be	33.3	0	66.7
5.	Is the navigation user-friendly?	May be	Yes	May be	33.3	0	66.7
6.	Are provided links useful?	May be	Yes	Yes	66.7	0	33.3
7.	Is interface design intuitive?	Yes	Yes	Yes	100	0	0
8.	Is the orientation and size of objects appropriate?	Yes	Yes	Yes	100	0	0
9.	Is this website free from complexity and tediousness?	Yes	Yes	Yes	100	0	0
10.	Is this website free from frustration and animations?	May be	Yes	Yes	66.7	0	33.3
11.	Are clickable areas positioned appropriately?	Yes	Yes	Yes	100	0	0
12.	Is this site causing user fatigue?	No	No	No	0	100	0
13.	Are the popup menus disturbing for the user?	No	No	No	0	100	0
14.	Are you satisfied with the labeling?	No	Yes	Yes	100	0	0
15.	Is provided content appropriate?	Yes	Yes	Yes	100	0	0

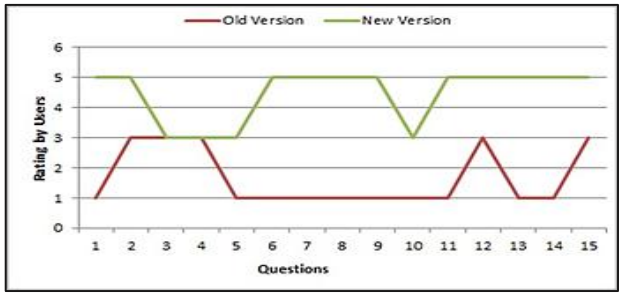


Figure XI: Comparison of New and Old Versions

It shows that majority of the identified flaws have been resolved by the implementation of the proposed model and user response is satisfactory for the majority of the concerns. In order to show the results of the old and new versions graphically, mapping is performed and the rating is converted to numerical values for each question; i.e., for low, 1; for medium, 3; for high. Figure XI shows the comparison of user responses for an old and new version of the selected interface.

B. Evaluation of Mobile Application

Apart from website evaluation, we have targeted mobile applications for usability evaluation. For this purpose, we have selected an academic educational application, i.e., ABC. The ABC is a digital interactive application. This digital platform is implemented by quite a number of institutions in Pakistan. ABC is a full-suite digital course creation and delivery platform for an intuitive online learning experience connecting academia, learners, and industry. It is a one-stop solution to hold online education, virtual classrooms, blended learning, and self-paced learning without dependence on any third-party solutions. ABC is a kind and wholesome E-learning solution in Pakistan.

1) Evaluation Methodology:

In order to evaluate the ABC mobile application, it is explored, used, and assessed against usability principles that to what extent is this application usable for its intended users. Exploration of disclosed its usages in terms of provided features, functionalities, interface, and design. However, it resulted in the identification of a number of existing usability flaws and bugs as reported in Section VI-C. The identified usability flaws are resolved by following model guidelines.

C. Usability Flaws in ABC

A link to the web portal is provided by ABC mobile application. Although this link is helpful in directing the user to a web-based interface; however, difficulty arises for the user for understanding as the option of the web portal is not appropriately labeled as shown in figure XII. Due to these readability issues user is unable to understand the actual purpose of this option. This usability issue violates the understandability principle of usability.

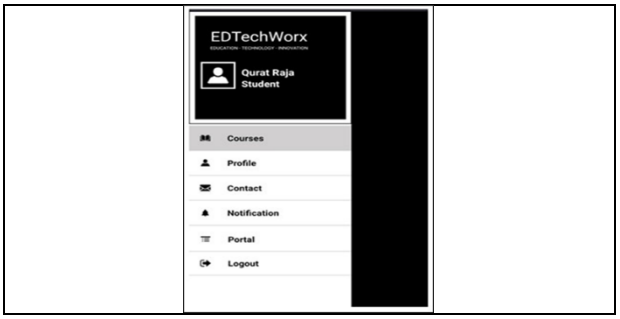


Figure XII: Inappropriate Labelling: Understandability Issue

Error recognition and recovery play a significant role in usability to enhance user experience with the application. In this application, if a user enters the wrong password, the system sometimes (not always) does not provide an alert

and wipes off the data as shown in figure XIII; thus violating the effectiveness principle of usability.

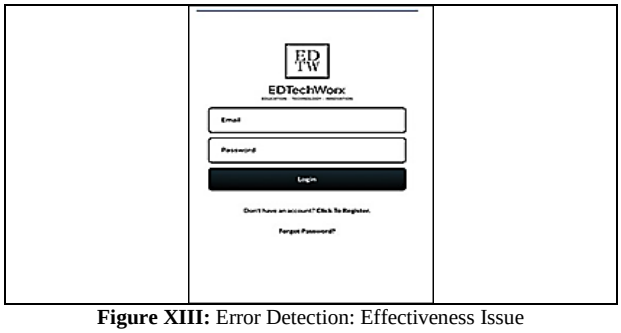


Figure XIII: Error Detection: Effectiveness Issue

The application provides assessment-sharing options. However, multiple icons with maximum similarity and no textual labeling are present in the interface as shown in figure XIV. It causes cognitive load for the users thus violating the understandability and learnability principles of usability. However, to make it more understandable for the user, it can be replaced with more relevant textual icons resulting in enhanced understandability and learnability and; thus enhanced usability.

If a user clicks on the certificate or courses option, it shows a blank screen in case the user holds no certificate or course as shown in figure XV and figure XVI.

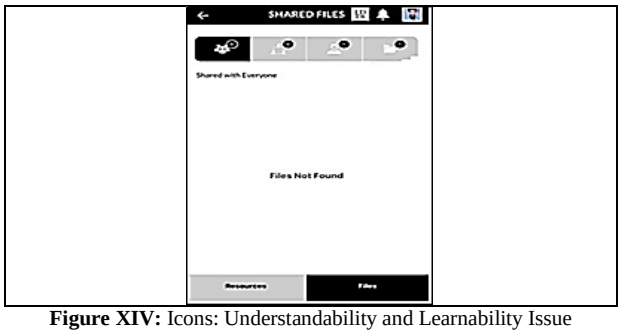


Figure XIV: Icons: Understandability and Learnability Issue

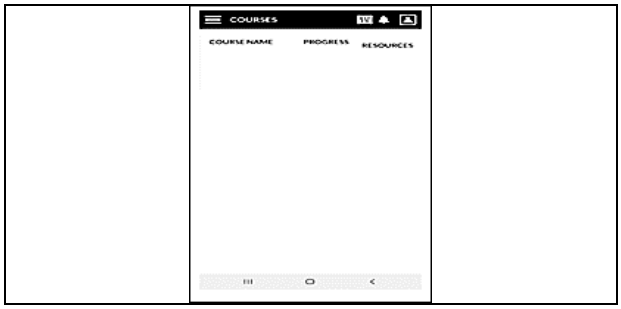


Figure XV: Courses: Understandability Issue

Figure XVI: Certifications: Understandability Issue

However, it can be designed to be more understandable by showing a clear message to the user if he owns no course or certificate.

Sometimes, the button labels cut off on small screens as shown in figure XVII thus violating the understandability principle of usability.

Figure XVII: Incomplete Button1: Understandability Issue

1) Applying UDLC Model to Redesign ABC:

ABC is selected for improvement purposes to evaluate the quality and efficacy of the proposed model. In order to address the usability issues reported in Sub-section VI-C, we intend to redesign the reported usability issues by following the guidelines of our proposed model, i.e., UDLC. As we are not completely designing a new application but rather fixing the usability issues in the existing one; we intend to cover level-1 till level-3 for fixing the identified issues. However, for level-4 till level-7, we provide recommendations that should be applied while any such interactive application is being designed.

- Level 1: Starter

At this level, objectives are set and the goal is defined. The objective in the current scenario is to redesign and fix the usability flaws identified in EDTW. Moreover, a tool used for redesigning is decided, i.e., 'MockFlow' (https://mockflow.com/app/Wireframe), an online application for designing.

- Level 2: Determination of Usability Objects

At this level usability objects (concrete requirements) are determined. As we are not designing the application from the scratch, instead we are intended to fix the usability issuesin the existing one; therefore, we consider the identified usability issues as our usability objects. Hence, the usability objectsfor our new version are those already reported in Sub-sectionVI-C. We aim to fix the reported usability issues and redesign the improved version of the interface. The identified users ofthis new design are the same as that of the old, i.e., academicusers (faculty members and students at the university level).

- Level 3: Creating Usability Design

Once usability requirements and the intended users are clearly identified and reported, the improved interfaces are designed against each of the reported usability issues. The design is rebuilt using the tool specified at level-1. The usability objects determined at level-2 and the intended users are continuously considered while the new interface is being redesigned.

To cope with the understandability issue that arises when the user is to be directed to the web portal, the portal option is appropriately labeled as shown in figure XVIII. To fix the issue associated with error recognition and recovery, the interface is facilitated with error detection as shown in figure XIX; thus addressing the effectiveness principle of usability.

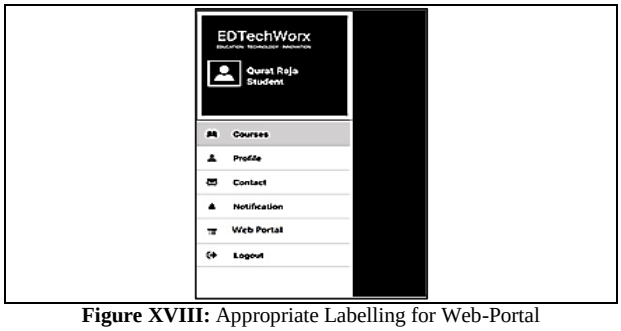


Figure XVIII: Appropriate Labelling for Web-Portal

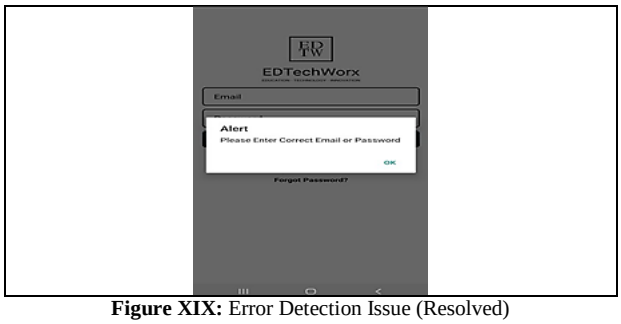


Figure XIX: Error Detection Issue (Resolved)

To reduce the cognitive load for the users caused by multiple icons with maximum similarity, the assessment-sharing interface is redesigned by replacing it with more relevant textual icons and text-based labels as shown in figure XX; thus addressing the understandability and learnability principle of usability.

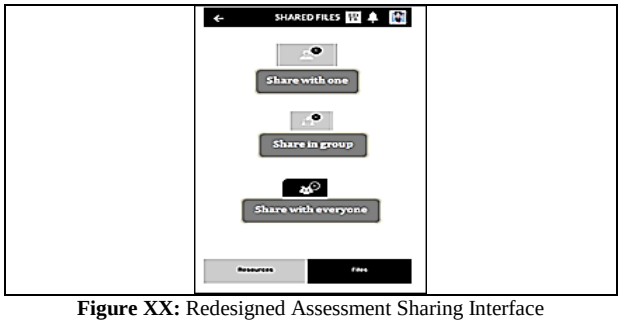


Figure XX: Redesigned Assessment Sharing Interface

Figure XXI: Redesigned Interface for Courses

Figure XXII: Redesigned Interface for Certifications

Moreover, usability issues associated with Courses and Certification options are fixed by adding clear messages (as shown in figure XXI and figure XXII). These redesigned interfaces address the understandability principle of usability mainly targeting users who own no course or certificate.

Furthermore, button labels are redesigned as shown in figure XXIII to avoid cutting off on even small screens; thus transforming the interface to be more usable.

Figure XXIII: Redesigned Button1 Interface

- Level 4: Usability Testing and Validation

When an interactive application, such as ABC, is complete, it should be tested before releasing to the end users. This testing would help to discover usability defects, bugs, and issues in the application that can later be resolved and fixed before release. It would also help to determine whether the application fulfills the usability objects that were identified at an initial level of the usability process. It would be appropriate to conduct this testing after the design phase to assure that, whether user expectations and needs are sufficiently addressed or not. Some suitable strategies for heuristic validation should be performed. The ultimate goal of this pre-release heuristic validation would be to ensure the desirability of the user in the product. The application design should be validated against application-specific heuristics.

- Level 5: Usability Measurement

To ensure maximum usability, usability measurement should be performed. Some suitable strategies should be applied for usability measurement. It would help to understand the perceived usability of an application for the user in a quantitative way.

- Level 6: Installation and User Feedback

Once the application is complete and formalities of usability testing and validation are performed, it should be installed and deployed for the user. User feedback should be taken. This feedback should be further worked on to fill in any missing gaps or issues reported by the user. After deploying users must be tracked and usability defects data should be collected followed by addressing those defects to minimize identified usability bugs.

- Level 7: Strengthening Post-Delivery Services

Users should be availed of a platform where users can report their queries or concerns and designers can address them through this channel. Providing an interactive portal to the users would help improve the overall usability of the product. Moreover, all those social media and forum sites that can be helpful for users in coping up with usability issues in some way should be updated.

D. Ethical Consideration

Ethical values are considered throughout the conduct of this research. Ethical code of conduct is adhered to during taking evaluation surveys from users. Participation of users is ensured to be voluntary, informed, and with their consent. They were free to participate without any pressure. Moreover, to maintain confidentiality, users' personal information is kept safe and private. Researchers knew who the participants are however that information is kept hidden from everyone else. The identities of the participants are kept confidential and are not published in the research report. The chosen application for the evaluation purpose is targeted after taking the consent of owners by clearly informing the purpose of the evaluation. Furthermore, adhering to ethical values, this research study is ensured to be free of plagiarism and any other misconduct. Compiled results are honest and reliable. Hence research ethics are considered and followed to maintain the scientific integrity of this research.

VII. DISCUSSION

Despite existing usability practices, a large number of gaps and challenges are seen to be unaddressed. Such usability gaps and challenges demand the need for a framework or a maturity model that should efficiently target the unaddressed gaps and deficiencies in the area of usability. To address that need, this research study proposes a systematic and comprehensive maturity model. The proposed model is comprised of seven levels as shown in figure V. As this model is exclusively responsible to mature the usability attribute in process of software production and would run parallel to Software Development Life Cycle (SDLC), therefore it is assigned the name Usability Development Life Cycle (UDLC) model. To ensure the easy and smooth execution of the proposed model, a detailed and comprehensive set of guidelines is also proposed along with the model. In the UDLC model, usability practices are introduced by considering not only large-sized organizations but also special consideration is made to small and medium-sized organizations. The model is verified and validated for its competency by applying on poor websites and mobile applications with weak usability and unsatisfied user experience. Execution of the proposed model on the targeted samples resulted in enhanced usability with maximum user satisfaction. However, this study still has a few limitations, i.e., justification of the proposed model with a proper mathematical model and usability measurement tools and techniques. The listed limitations are intended to be covered by the continuation of this research in the future.

VIII. CONCLUSION

To overcome such existing gaps, this study targeted to propose a systematic and comprehensive maturity model, i.e., the Usability Development Life Cycle (UDLC) model along with a set of guidelines. The model is verified and validated for its competency.

However, the study has a few limitations as the proposed model is not yet evaluated by using quantitative measures. Moreover, the proposed model is still lacking such usability measurement techniques that could numerically measure usability. The future work of this research would be to enforce and promote the practical execution of this proposed model. In order to increase the acceptance rate of this model, we also look forward to verifying and evaluating it by some quantitative values and results. A software tool may be designed to quantitatively measure the usability of interactive software and applications.

Acknowledgment

The authors would like to thank the National University of Sciences and Technology, Military College of Signals, Pakistan for all the support provided to accomplish this research work.

Authors Contributions

Qurat Ul Ain contribution to this research study was model and guidelines design, methodology, paper writing, and correspondence. Tauseef Rana performed supervision and validation. Aamana contributed to data collection and analysis.

Conflict of Interest

There is no conflict of interest between all the authors.

Data Availability Statement

The testing data is available in this paper.

Funding

This research received no external funding.

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