INTEGRATING AHP INTO HEURISTIC EVALUATION TECHNIQUE TO ENHANCE USABILITY EVALUATION PROCESS

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This study is dedicated to my parents and grandmother, who have been the cause of constant inspiration and gave me their constant moral support, prayers and provide their emotional, moral, spiritual and financial support.

Thanks for always standing by my side in all these years.

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ABSTRACT

Today people increasingly expect more from the functionality of a web site, so usability evaluation has emerged as an important topic. There is an increasing importance for higher usability in the web development industry and communities. This has necessitated the urge and drive for effective usability evaluation techniques. However, the need to measure usability of websites effectively have also prompted many researchers to develop different usability evaluation model. Different usability evaluation techniques have been developed and incorporated into the process of web site design and development. The research is aimed at improving the usability evaluation particularly heuristic evaluation technique by solving usability problems of Coursera as a Case Study. To this end, Heuristic Evaluation (HE) was comprehensively studied and its limitations were identified with the help of the case study. HE helps to identify usability problem but does not offer any framework to prioritize the most important heuristic and sub-heuristic. To improve the Heuristic Evaluation Process there is a need to create a framework that is based on the prioritization of the factors using Multi Criteria Decision Making Analysis (MCDA). Analytical Hierarchy Process (AHP) was integrated into HE to prioritize and rank usability issues. Based on findings a framework to enhance the severity ranking is developed

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LIST OF ABBREVIATIONS

MOOC - Massive open online course

MCDA - Multi-Criteria Decision Analysis

AHP - Analytic Hierarchy Proces

SUS - System usability Scale

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CHAPTER 1

INTRODUCTION

1.1 Background

The quality and consumer acceptability of a product mostly depends on the ease-of use, physical, mental and psychological characteristics which are more important than the technical properties of the product. Consumers pay more attention to the ease-of-use property of a product [1]. Therefore, designers, e.g. those of software design and consumer products, are aware that their products need to be designed so that users can use the products to a satisfying degree. The designers aim for products with high usability. Usability is not a single property, but a combination of several properties and attributes [2]. According to the standard ISO 9421-11, that usability is the effectiveness, efficiency, and satisfaction with which specified users achieve specified goals in particular environments.

Different usability evaluation techniques have been developed and incorporated into the design and development of web sites. Among these techniques, user testing and heuristic evaluation (HE) are perhaps two of the most popular ones [4]. HE refers to a class of techniques evaluators use to examine an interface for usability issues. HE outlines the usability problems in user interface designs based on the usability heuristics. Numerous sets of heuristics can be applied during HE. Many of them have common usability principles such as consistency, task match, appropriate visual presentation, user control, memory-load reduction, error handling and guidance and support [2]. The most commonly used heuristics

are Nielsen's ten heuristics, Shneiderman's eight golden rules of interface design and Norman's seven principles [5].

Analytic hierarchy process (AHP) is a powerful decision analysis technique in the area of multi-criteria decision-making method, developed by Saaty [6]. By the method it is aimed that decision makers make more efficient decisions. AHP is a method that relies on human judgments in decision making process and, qualitative and quantitative criteria can be combined. This method is applied to many real life decision making situations, and is used in different fields such as selection, evaluation, planning and development, decision making, forecasting, and so forth [7]. Especially, the AHP method is integrated in a design method for developing new products and interface [8].

1.2 Research Gap

- The existing research focuses more on identifying the issues and proposing solution but lacks to pay attention to the prioritization of the issues [12].
- HE is relevant because of its capabilities in assisting evaluators to identify usability problem in the early stage of development process but does not offer any framework to prioritize the most important heuristic and sub-heuristic [14]. The proposed research suggests the integration of AHP with heuristic evaluation to render better results.
- Due to the wide applicability and ease of use, the analytic hierarchy process (AHP) has been studied extensively for the last 20 years. Recently, it is observed that the focus has been confined to the applications of the standalone AHPs rather than the integrated AHP [15].
- This research not only provides evidence that the integrated AHPs are better than the stand-alone AHP, but also aids the researchers and decision makers in applying the integrated AHPs effectively.

Due to the wide applicability and ease of use, the analytic hierarchy process (AHP)

has been studied extensively for the last 20 years. Recently, it is observed that the focus has been confined to the applications of the standalone AHPs rather than the integrated AHP. This paper reviews the literature of the applications of the integrated AHPs. Related articles appearing in the international journals from 1997 to 2006 are gathered and analyzed so that the following three questions can be answered: (i) which type of the integrated AHPs was paid most attention to? (ii) which area the integrated AHPs were prevalently applied to? (iii) is there any inadequacy of the approaches? Based on the inadequacy, if any, some improvement s and possible future work are recommended

In an evaluation process, finding flaws earlier rather than later able to reduce usability errors, which may be more costly to rectify once the application, is completed. This is when the HE is relevant because of its capabilities in assisting evaluators to identify usability problem in the early stage of development process but does not offer any framework to prioritize the most important heuristic and sub-heuristic. The proposed research suggests the integration of AHP with heuristic evaluation to render better results

1.3 Problem Statement

To improve the Heuristic Evaluation Process there is a need to create a framework that is based on the prioritization of the factors using Multi Criteria Decision Making Analysis (MCDA). Due to the wide applicability and ease of use, the analytic hierarchy process (AHP) has been studied extensively for the last 20 years. Recently, it is observed that the focus has been confined to the applications of the standalone AHPs rather than the integrated AHP. This paper reviews the literature of the applications of the integrated AHPs.

1.4 Aims and Objectives

To this end the fundamental goals of the research study were:

1. To study the Heuristic Evaluation Process for finding out its limitations and flaws in previous study
2. To integrate Multi-Criteria Decision Making Analysis tools like AHP into Heuristic Evaluation
3. To improve the severity ratings of heuristic evaluation technique

1.5 Key Research Questions

RQ-1 What are the deficiencies limitations of Heuristic Evaluation Technique?
RQ-2 Which quality factors are most important and needs priority for the enhancement of MOOC Platforms?
RQ-3 How to improve severity rating process?

1.6 Research Scope

As far as the research scope of present study is concerned, this research work is thoughtfully designed to enhance usability evaluation technique. It will propose a thorough evaluation and quality assessment mechanism that will yield reliable results. The scope of this research includes theoretical background, questionnaire designing phase, data collection process, the research findings' analysis, and conclusion.

1.7 Main Contributions

Our contributions include:

1. Identifying the issues of Heuristic Evaluation Process
2. Improve the Severity Ranking Process of Heuristic Evaluation
3. Propose a framework for effective decion making by Integrating AHP into Heuristic Evaluation

1.8 Thesis Organization

Chapter 1 covered the main idea, contribution, significance, aims and objectives and basic contributions of this research study.

Chapter 2 will discuss the details of the related work and literature which has already been performed in past.

Chapter 3 targets the methodologies and procedures which are being used in this research study which includes heuristic evaluation and AHP. The questionnaire design of the methods, data gathering and analysis method.

Chapter 4 comprises all the results and discussions by implementing heuristic evaluation and AHP formulas in MS Excel.

Chapter 5 confer the conclusion and future work

The graphical depiction of thesis organization is shown in Figure 1.1 below:

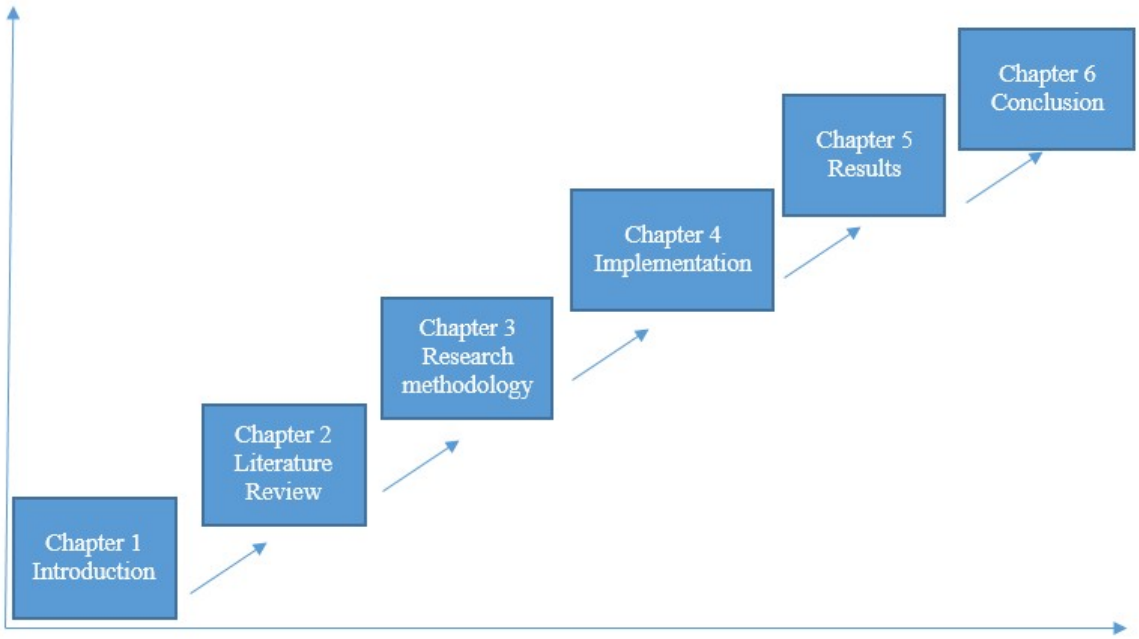


Figure 1.1 Thesis Organization

1.9 Chapter Summary

There are certain limitation in the Heuristic Evaluation technique as it focuses on identifying issues but does not provide framework to suggest the most important and least important issues. The study focuses on improving the severity ranking process of Heuristic Evaluation by integrating effective Decision Making Strategy.

CHAPTER 2

LITERATURE REVIEW

This chapter comprises all the key concepts that are related to our research work and this will also enlighten the maximum related work which has been performed till the date.

2.1 Key Concepts

This section will describe the key concepts related to this research work.

2.1.2 MOOC Platforms and its effectiveness

The present study looks at the improvement of UI (User Interface) MOOC platforms and its effectiveness. A plethora of research has been provided over the significance of UI, therefore, the reason behind choosing UI in MOOC platforms is because limited human interaction is provided by MOOC between instructors and learners, and same like computer system design or software production's field that does not provide the user a wider interaction. That is why the use of simple UI is necessary in MOOC because it helps the user in navigation as well as understanding each instruction despite having a limited human interaction or support [20] [21]. It has been argued by Galitz that a UI which is well designed is very significant for learners in MOOC. If the information presentation or design seems to be very inefficient and confusing, many difficulties would be faced by learners to achieve the outcomes. If the UI is poorly designed, it would eventually lead to the learners

experiencing increased stress, frustration, and aggravation. A poorly designed interface can also lead to frustration, increased stress, and aggravation Particularly addressing User interface in any learning setting, it was identified by Najjar in 1998 that there are 5 design principles that can play their immensely significant role in enhancing learning which includes making UI interactive, using elaborating media, presenting multimedia synchronously. The use of multimedia should be supportive rather than decorative while using a medium that can play its role in conveying information [26]. For users, UI in MOOC needs to be quite useful since it should not only focus on the task of users that what are the important parts, but also permit learners to interact with application in several ways that are known to be normal as well as instinctive. Thus, the UI needs to be simpler for the users" better understanding [28] Friendlier software having lots of constrained abilities is regarded to be quite usable since the Ul has a great impact over the software products" quality [26]

2.1.3 Under Study MOOC Platforms

Coursera is a revenue-driven organization that has an incredible collection of courses that is yet developing quickly. The platform was made without any preparation in 2013. Currently, Coursera is the biggest of MOOC suppliers and has some 30 million enrolled students in total [8]. Coursera's mission is to make it possible for people to access the world's best training from top colleges and associations worldwide and to offer courses online for anybody to take. Today, almost 100 colleges and associations from around the globe are Coursera's benefactors or accomplices. In December 2013, Coursera presented a mobile-friendly form. The organization also organizes modern educational centres in areas where the attainment of knowledge by staying at home is much difficult. Normal Coursera course comprises short video addresses, reading materials, assignments, tests, and final exams, peer-reviewed appraisals. After each exercise, understudies need to breeze through tests or assignments. Typically, every test or assignment has a due date. Understudies enrolled can connect with fellow individuals on discussion forums or at social media platforms.

2.1.4 Literature review to identify usability factors

The three core components of UI in an educational platform are. Visual zone - the user interface. The functionality of the platform, including devices to perform learning exercises. User-system connection process. The focus of all software developers has been on the system's functionality most of the time. In that process, they unknowingly ignore the other most important component of developing an educational platform, that is, the User Interface [20]. Even though functionality and user interface are differentiated, the user of a system is unable to identify these as two distinct components [35]. They feel that UI is basically the actual platform since they see working with an application as working in a system interface. Therefore, for a system to be usable for the user, its UI must first align with the following key rules.

- The user interface of the system must promote and nourish the learnability factor. A user must be able to learn the art of interacting and using that system.
- The interface must match with the real world so that the user does not feel any difficulty incomprehending how to use it.
- The entire educational procedure must be continuous and permit to work easily.
- The instructions given must be clear and justifiable.
- The actions performed by a user must not lead them to a situation where the user is unable to proceed further.
- Content must be concise and understandable.
- User must address his or her slip-ups in a quick way.
- Site route must be natural.
- User must also be able to track his progress using the platform [36]

It has been said by Karsenti that it might be called careless if someone makes speculation about the user's experience level with them. Because it has been shown by the statistics that a lot of users get registered for MOOCs every year worldwide, and the Internet buzzes with blogs as well as articles by referring to their educational advantages. Thus, their popularity

cannot be denied [37]. That is why the present study aims to evaluate the usability of MOOCs to determine its effectiveness and usefulness. However, some researchers conducted by the researchers on the usability of MOOCs have assessed the poor success rate of MOOCs with high dropouts and low competition rates. And these statistics seem contradictory to their users' high number and popularity [10-13]. Furthermore, it has been contended by Chuang et al that because of the absence of the studies about MOOCs' use and their usability, neither guidelines nor standardised way to develop as well as evaluate have been suggested. According to Emanuel et alit makes the user interface design a "no man's land" where every MOOC is designed according to its creator's own standards, resulting in various qualities [13]. Less evaluation of the usability of MOOCs leaves a huge research gap in the research field; therefore, the current study aims to identify the major usability issues of MOOCs. MOOCs can challenge a user which does not have any concern with the difficulty level of the content of course. Consequently, it compels the user to learn to use the application before the fulfilment of their educational objectives. According to Hassenzahl, We are taught by experiences that designing a product require its users' detailed understanding along with the context in which the product is used. When it comes to learn online through MOOCs, it is of great importance. The current research covers the research gap by investigating how MOOCs' usability plays its role in affecting interaction between interface and users.

2.1.5 Heuristic Approach

Heuristic evaluation is one approach to evaluate usability. It is a process of detecting the usability obstacles in a user interface. This is done by having few evaluators and dig into or study the interface and check whether the developed interface has concurrence with the customary usability principles [45]. The most promptly used methods for inspecting usability is heuristic evaluation [46]. It contained sets of heuristics which are the broad rule of thumb and are used for assessing usability [46]. The heuristic approach was proposed by Nielsen and Molich so that the issues in the user interface could be identified and they can appear as an element in the iterative design process [47].

The one main advantage of heuristic evaluation is that it is quick and is less expensive. Nielsen's heuristics are being widely used for the usability evaluation process however few authors modify these heuristics according to their work and methodology[46]. According to Nielsen, it is difficult for one person to evaluate because he/she may not be able to find all the possible issues hence it is advised to consider multiple evaluators for the purpose [47]. Ger Joyce et al [48] discussed a conflict or difference of point of view of different authors and stated that few authors think that the results from the heuristic evaluation are too subjective whereas some are of the view that this difference of thinking can make it possible to find more diverse usability issues [48].

The main concepts of heuristic evaluation are the same and they are being vastly used for evaluation. Below are the ten usability heuristics which are defined by Jakob Nielsen and are stated as below [49]:

1. **Visibility of system status** [49]

This point affirms that the user should always get information about what is happening while using the system from the system and will give applicable feedback at an appropriate count.

2. **Match between the System and the real world** [49]

The system should be end user friendly in the sense that it uses all the terms, clauses and concepts which are compatible with the user's understandings rather than the system language or we can say that**:** the interface language is simple? Are the terms, clauses and concepts which are being used familiar to the user?

3. **User control and freedom** [49]

Sometimes users get their selves in the unwanted situation by clicking on the wrong links etc. There must be undone options and clear instruction to revert unwanted actions so that users can get back to a normal state. Support redo and undo options.

4. **Consistency and Standards** [49]

The system should follow the platform conventions means the system should have proper icons, words etc for everything and users should not confuse while performing similar actions.

5. **Error Prevention** [49]

Good design is that in which there are no or minimum errors but if there exist some errors there should be error prevention. Is making errors easy? If yes, then where and why? And if an error comes then there should be the option of error prevention. If there exist chances of error then that should be eliminated.

6. **Recognition rather than recall** [49]

Instructions on the system should be visible to the users in such a way that they don't have to remember the actions, objects and options to perform tasks. User must already recollect the actions to be performed instead of recalling them or we can say that are the options and actions are always visible.

7. **Flexibility and efficiency of use** [49]

This point describes that the accelerators mean shortcuts should be given to use the system so that both the novice and expert users can use the system efficiently and in a user-friendly way.

8. **Aesthetic and minimalistic design** [49]

The information visible on the system should be the one which is of most importance. The presence of irrelevant information reduces the impact of relevant information. The information must be concise.

9. Help user recognize, diagnose and recover errors [49]

If there is a chance of error occurrence and error occurs then the message to the user should be delivered in the human language, not in the code language. The error message should describe the issue in the simplest possible words and prevent a solution.

10. Help and documentation [49]

Help related to the system should be provided in a proper documented form. Information should be easily accessible so that novice users can get help where needed.

The turnout after performing the heuristic evaluation will be the list of all the usability issues which disrupt the usability principles. The evaluators are needed to explain the issues according to the heuristic guidelines [47].

2.1.6 Multi-Criteria Decision Analysis (MCDA)

The MCDA implicate the natural world problems interpretation using both the qualitative or quantitative criteria in the definite and indefinite delicate environment. The main objective is to acquire conveniently direction, choice and scenario amidst different available options [50]. This MCDA is extensively being suitable in different areas such as education, engineering, evaluation, selection and others [50].

The MCDA approach has been segregated into two categories: the first one is Multi-attribute decision making (MADM) and the second is Multi-objective decision making (MODM). The MADM methods incorporate human participations and judgements which is unlikely in MODM methods [51].MCDA is considered a comprehensive phrase for all the approaches that exist and assist people to decide where exists more than one contrary criteria according to their inclination [52]. The use of MCDA methods helps in bettering the decision aspect and this is done by creating the development more specific and rationale [52].

MCDA is considered as one of the beneficial tools in many selection problems such as education, military, material and a few others. Many techniques have been proposed to find the answers to the multi-criteria decision problem to date [53]. A few of the effective MCDA methods are:

- AHP
- Fuzzy AHP
- TOPSIS
- ELECTRE
- VIKOR
- PROMETHEE

2.1.7 Analytical Hierarchal Process (AHP)

The Analytical Hierarchal Process (AHP) is one of the procedures of multi-criteria-decision analysis and is refined by Saaty [54]. AHP is being used by many authors in their research work is one of the popular methodologies for multicriteria decisions [54]. Saaty in his research paper described AHP as a measurements generic theory [55]. AHP uses both discrete and continuous pair comparisons to formulate the ratio scales [55]. In the normal form, AHP is considered as a framework that is non-linear that is used for accomplishing both deductive and inductive thinking by considering different factors in discussion [55].

The following steps are used to perform the AHP [56]:

- The created decision goal's evaluation criteria are determined at the first step and then a hierarchical framework is created.
- The pairwise decision elements are correlated.
- The relative weights of decision elements are calculated.

- Established on the aggregated weight of decision elements, rate the decision alternatives [56].

The hierarchy of the AHP is displayed in Figure 2.1 below:

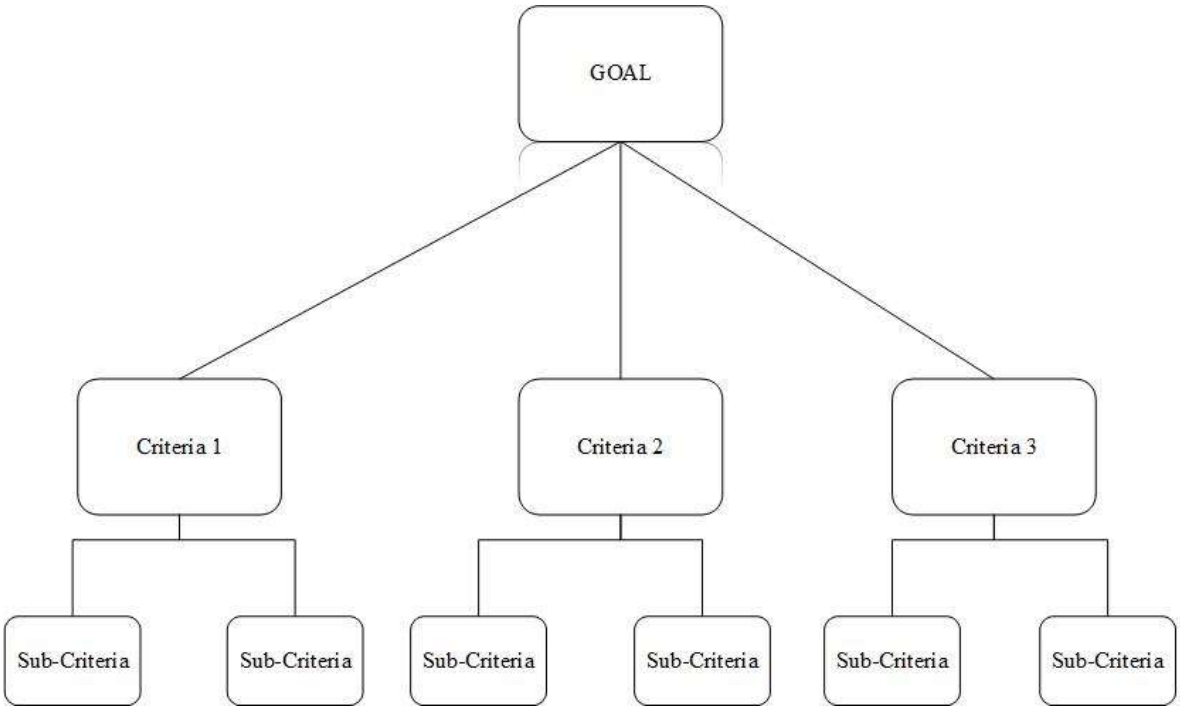


Figure 2.1 AHP Hierarchy

AHP has been used in almost every type of MCDA because it has flexibility, is easy to use and simple[56]. The factors can cause some confusion for the person who doesn't have much knowledge and cause them to think t hat which factors to include and which to exclude. According to Saaty at the stage of creating hierarchies, representing the problem as efficiently as possible requires adding enough relevant details that can explain the problem as well as doesn't make it look more complex [57].

2.2 Related Work

Table 2.1: Related Work

Sr.	Author	Year	Methodology	Benefits/Reason for usage	Limitation	Approach
1	Anam Arshad, Javed Anjum Sheikh [64]	2016	Heuristic Evaluation Method	This method is inexpensive and easy to do	Taking into consideration need of the user	User's mental model also taken into consideration while redesigning the website
2	Barbara S Chapparo [60]	2008	AHP based Algorithm	The literature proved the usefulness of the AHP Algorithm	Work has been done in a limited environment of laboratory	Quality assurance of academic websites using usability testing
3	Sharmistha Roy, Prasant Kumar Pattnaik, Rajib Mall [63]	2016	AHP, Questionnaire	Suits best for taking complex decision	Usability evaluation on three academic websites	Highest usability scored website among 3 websites
4	Ismailova, R, & Kimsanova [65]	2017	Heuristic Evaluation Method	Methodology used here was useful for multiple criteria decision making in fuzzy environments	Sample Size was small	Accessibility & usability
5	Hmood Al-Dossari	2017	Heauristic Evaluation Method	This method is inexpensive and easy to do	Study of a usability evaluation of an online academic	Enhance the usability of online portal

					portal of King Saud University	
6	Tsai, C.W., Shen, P.D., & Chiang, I. C. [68]	2018	Fuzzy Analytic hierarchy process	Proved to be useful for enhancing students' performance	Did not consider learning environment	Designers need to work on MOOCs more for enhancing students learning experience
7	Gülin Feryal Can, Seda Demirok	2018	multi criteria decision making approach	propose an integrated fuzzy approach to determine important universal usability problems (UUPs	Sample size was small cannot be generalized	to establish a work plan to correct the most important ones
8	Watted A. & Barak [67]	2018	Heuristic Evaluation Method	It helped finding out motivating factors behind MOOCs	Comparison of university affiliated students and general participants but their sample size was not big that could have been generalized	University affiliated students were more attracted to MOOCs than general participants
9	solomon a. adepoju, adamu a. mohammed	2019	Usability Evaluation	Integrated usability evaluation framework for university websites	Research challenges defined with limited scope	handle both the subjective and objective aspect of usability evaluation thereby eliminating bias

						exhibited by human being during evaluation.
10	Suryadi Hadi, Ali Murad, Cikal Rambase Nasution	2020	AHP	To classify student behavior in the use of e learning	Have not used any hybrid technique to access the quality usability	ensure a better ranking and classificati on of the usability of the selected websites.
11	Wen Qi Paite Yang	2021	Integrating AHP with usability testing	Helped in prioritizing usability issues	Sample size was not big that could be generalized	combine the analytic hierarchy process (AHP) with usability test to understand the goals

2.3 Chapter Summary

Heuristic Evaluation solely focuses on identification of problems and giving a prototype but does not provide appropriate framework for prioritization of Issues/ severity ranking.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter covers the work methodology that is used by the researcher for this research study. It includes the details of the selection MOOC Platform, procedure, and evaluation through an integrated heuristic approach and AHP. Previous studies indicate that heuristic and user testing approaches are most commonly used methods in evaluating the usability of e-learning platforms. Heuristic evaluation is quick technique to identify the UX/UI issues in user interface of MOOC Platforms; based on established heuristics. To justify this argument, a literature review has been conducted by the author on usability evaluation of e-learning platforms in chapter 2. This chapter also warps up the Nielsen scale for heuristic evaluation to rank the usability problems along with explanation regarding the MCDA Technique. Many authors have defined usability in many ways. Usability is the name of ease of use and learnability of products. Usability means how quickly users use a product and learn to use it for the first time. International organization for standardization (ISO) defined usability as: “The degree to which any software product can be used for achieving specific goals by specific users in the specific context of use with efficiency, effectiveness, and satisfaction [14].

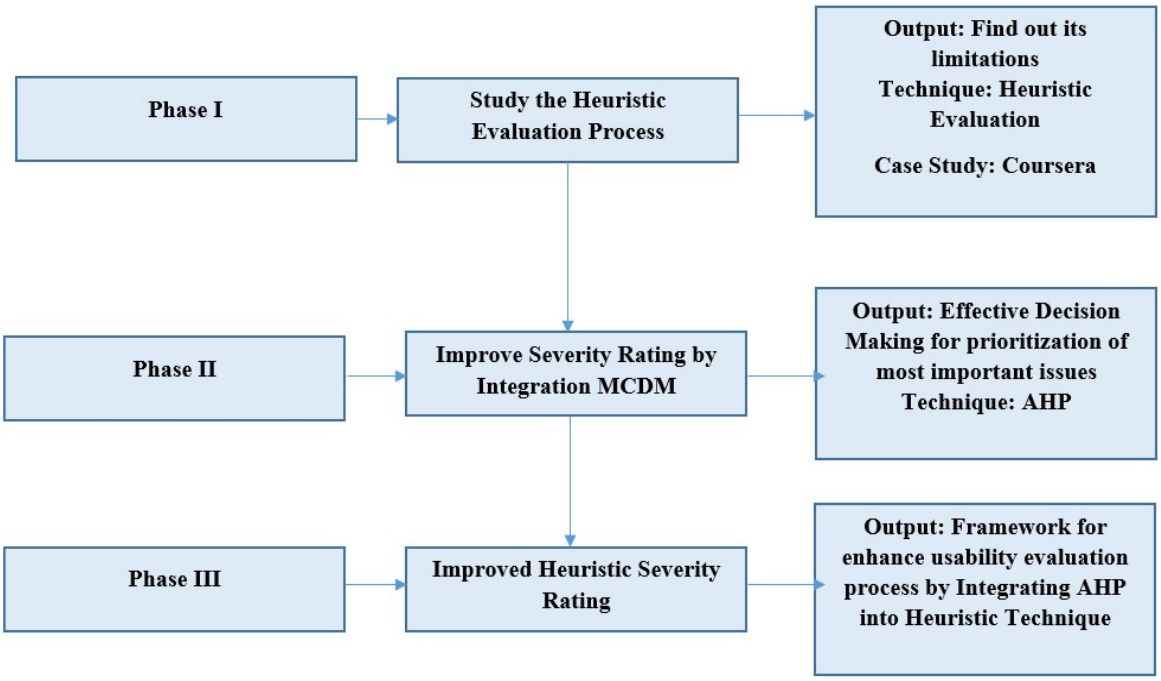


Figure 3.1 Research Methodology

3.2 Platform Selection

In this study, the first aim was to choose MOOC Platform as a case study for usability evaluation. The procedure that was selected by the researcher was based upon the popularity and current users satisfaction level of these MOOCs. The research reviewed 6 MOOC Platforms and selected 1 of them with the highest reviews and rating.

Table 3.1: User reviews of MOOC Platforms

coursera	Paid	8.6 Read review	(295 User Reviews)
SKILLSHARE.	None	8.5 Read review	(207 User Reviews)
LinkedIn LEARNING	Free	8.4 Read review	(122 User Reviews)
BitDegree	Free	8.3 Read review	(295 User Reviews)
Khan Academy	None	8.2 Read review	(261 User Reviews)
codecademy	Paid	8.1 Read review	(239 User Reviews)

3.3 Research Methods

The main purpose of this study is to evaluate and improve the usability evaluation process with the help of the case study. It aimed to discuss and analyse the results while making recommendations based on framework for MOOC Platforms in order to improve heuristic evaluation process. Various structured techniques are used to collect data such as online questionnaires. The online questionnaire is a major research tool. The findings of the questionnaire would then be discussed.

3.3.2 Phase 1: Heuristic Evaluation

Heuristic Evaluation is a widely used usability technique to find out usability problems in the e-commerce application interface in previous research studies. Heuristic Evaluation uses three to five experts to assess the user interface of e-commerce applications. There is no involvement of real users in heuristic evaluation. Expert users know usability guidelines which are proposed by different researchers in their studies. Neilson's Heuristic Guidelines Nielsen's Heuristic Evaluation Technique is a technique to test the usability in

which one or more than one usability specialist examines the user interface of a website through a set of Heuristics. A heuristic evaluation is a fast and less expensive way to evaluate the interface of your website [24]. Ten famous heuristics originated by Nielsen are:

- Visibility of system status
- Match between system and the real world
- User control and freedom
- Consistency and standards
- Error prevention
- Recognition rather than recall
- Flexibility and efficiency of use
- Aesthetic and minimalist design
- Help users recognize, diagnose, and recover from errors
- Help and documentation

Table 3.2 : Work Methodology Phase-Wise Steps

Enhancing Usability by Integrating Heuristic Evaluation with Analytical Hierarchal process
Phase 1 – Step 1 Selecting MOOC Platform, Coursra (Based on Popularity and Reviews)
Phase 2 Evaluation of MOOC Platform by Expert User (Heuristic Process)
Phase 3 Implementing AHP (Analytic Hierarchal Process) Prioritizing the factors that best suits for the usability of MOOC Platforms with experts' point of view
Phase 4 Develop Framework

3.3.2.1 Research Instrument

To collect the feedback from experts on heuristic evaluation, a questionnaire was distributed and asked the experts to rank each usability violation based on the result statement according to Nielson's severity ranking scale.

3.3.3. Analytical Hierarchy Process

The analytical hierarchy process was used to obtain the local and global weights of the usability issues for the ranking. The AHP consists of some steps which are being followed to obtain the required results. The basic AHP flow is described in Figure 3.2:

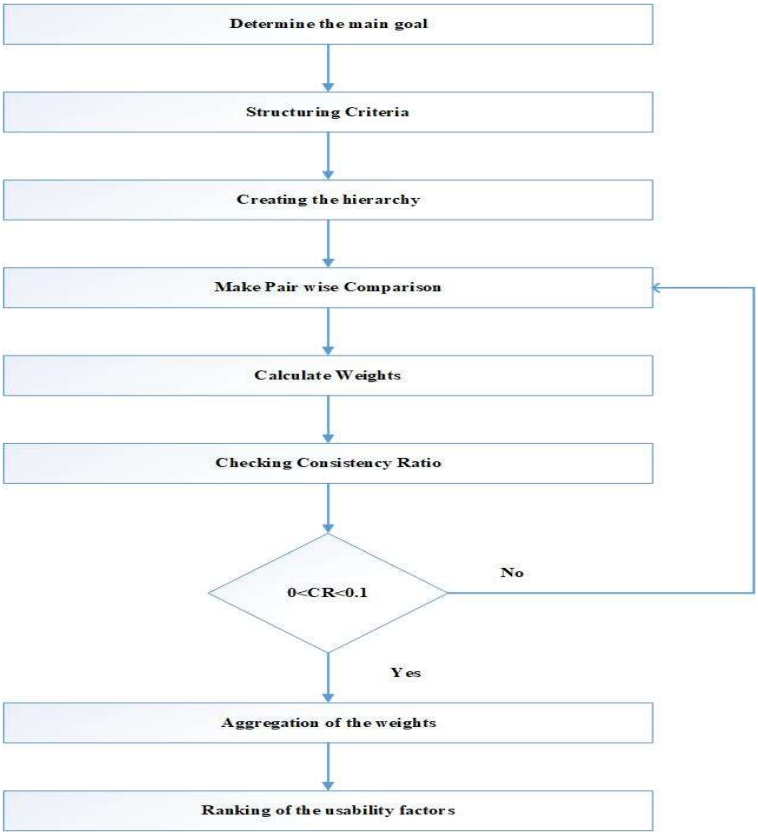


Figure 3.2 AHP Flow

The steps of the AHP are described below in detail:

Step 1: Determining Goal

The first step of AHP is to determine the goal which we have to achieve. In our research, our goal is severity rating/ranking of usability issues that are found and are classified.

Step 2: Structuring the Criteria and Sub-Criteria

After defining the goal, the next step is to define the criteria and sub-criteria. The selection of the criteria and sub-criteria is defined in chapter 2.

Step 3: Creating a Hierarchy

The creation of the AHP hierarchal structure is necessary to achieve the defined goal. The structure is hierarchical and comprises of main goal, criteria and sub-criteria. The completion of each hierarchy is compulsory to achieve the defined goal. The main criteria are user perspective, design perspective and system perspective. Each criterion has sub-criteria. The hierarchical structure of AHP is shown in Figure 3.3 below:

Step 4: Make Pairwise Comparison Matrix

To make a pairwise comparison matrix, we need to collect data from the experts. For this purpose, the questionnaire was sent to the experts and they were requested to fill the form. The questionnaire can be seen in Appendix B. After getting the filled forms, the pairwise matrices were formed based on the expert's feedback. The goal, criteria and sub-criteria for the pairwise comparison matrix are below:

The experts were asked to fill the form and made decisions for the pairwise comparison matrix through the sattys scale. The scale can be seen in Table 3.3 below:

Table 3.3 Satty's Scale

Explanation	Numeric Values
If Option A and Option B are equally important: select →	1
If Option A is moderately more important than Option B: select →	3
If Option A is strongly more important than Option B: select →	5
If Option A is very strongly more important than Option B: select →	7
If Option A is extremely more important than Option B: select →	9

Scale 2,4,6,8 was ignored in the questionnaire and pairwise comparison as these values are the intermediary values that do not affect the actual result.

Step 5: Calculating Relative Weights

After completing the pairwise comparison matrix step, the next step is to calculate the relative weights. These weights are calculated by calculating the average of the normalized values. The formula to calculate the relative weights is given below [78]:

$$kj = \frac{\sum_{j=i}^{m} nij}{m}$$

Where kj represents the weights of the decision matrix.

Step 6: Checking Consistency Ratio (CR)

The next step in AHP is checking the consistency ratio so that the effectiveness and validity of the expert's opinion. The pair-wise comparison of the experts will be accepted when the consistency ratio is less than 10%. If the consistency is more than the required value, then the data will not be used and will be sent to the user again to fill. The basic formula of the consistency ratio is:

$$CR=\frac{CI}{RI}$$

To calculate the consistency index, the formula used s given below:

$$CI=\frac{\lambda max-}{n}$$

Where λmax is the eigenvalue. The random index is calculated [78] as shown in the table 3.3 below:

Table 3.4: Random Index Values

N	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Step 7: Aggregating the Weights

After the calculations of the weights from each expert, there is a need to combine the results to get the overall weights. For this purpose, aggregation is performed by calculating the mean of the overall criteria and sub-criteria. The results obtained from the aggregation are further used to rank the usability issues.

The global weights are obtained by multiplying the local weights of the criteria with the local weights of the sub-criteria and global ranking is obtained.

Step 8: Ranking of the usability factors

After the calculations of all the global and local weights, the last and final step is ranking the usability factors. The factors are ranked based on their local and global weights.

3.3.4 Framework for effective decision making in Heuristic Evaluation by Integrating AHP

After obtaining the final results from the AHP, the last phase is to develop a framework for improved severity ranking. The local and global ranks are used to develop the framework. The details of the framework are given in chapter 4.

3.4 Chapter Summary

This chapter comprises a detailed discussion of the methodologies which are being used in the research work of this thesis. It discusses in detail all the methodological phases. The first step includes the heuristic evaluation of the chosen MOOC PLatform, then these factors were categorized into the criteria and sub-criteria. This categorization later used as a hierarchy of AHP. The data is collected through the forms and the calculations are performed through the MS Excel sheet and formulas are used. Later these techniques are used to prioritize the factors and a framework is created.

CHAPTER 4

IMPLEMENTATION

This chapter covers the comprehensive research phases including application selection, SUS (System Usability Scale) evaluation process of MOOCs Platforms paired with heuristic expert analysis and user testing from novice users, then integrating AHP with heuristic evaluation results to assign severity ratings to the issues identified in heuristic evaluation process. This chapter also includes the criteria and procedure adopted to select participants for the experiments and evaluation.

4.1 Heauristic Evaluation

4.1.1 Sample Size

The first step is choosing expert users for heuristic evaluations to find out the issues present in the two selected MOOC Platforms. For this purpose, we had a visit to the IT Software house and selected four expert evaluators for heuristic evaluation. All these expert users were having multiple years' experience of using MOOC Platforms particularly courser. Below Table 4.1 is giving the complete demographic of our expert users.

Table 4.1: Profile of Expert Evaluators

EVALUATORS	**EVALUATOR 1**	**EVALUATOR 2**	**EVALUATOR 3**	**EVALUAT--OR 4**
NAME	SHAHID RASUL	ZEESHAN KHALID	SHAHZAIB	IRFAN HAIDER
QUALIFICATION	MS CS	MIT	MIT	MS CS
PROFESSIONAL ROLE	Computer Lecturer and Online Course Trainer and Instructor at Beaconhouse	UX/UI Front End Developer/ and Instructor at Aitchison College	Web Developer and Network Manager/ IT Lab Instructor	Front End Developer and Graphic Designer
Coursera experience	6 years	5 Years	3 Years	2 Years

The expert evaluators assessed Coursera with Neilson's ten Heuristic. HE involves a set of experts to validate the usability guidelines on these applications during performing different tasks. In the process of heuristic evaluation, four expert evaluators were the users of Coursera. These expert evaluators were asked to perform a different checklist of tasks accordingly and match their observations with these integrated heuristics. These Integrated Heuristics are mentioned in Table 4.2 and also attached with complete checklist questions in appendix A section. These integrated heuristic guidelines were adopted from previous research studies [41][51] as mentioned below.

Table 4.2: Nielson's 10 Heuristics

Sr. No.	Heuristics
1	Visibility of system status and contents
2	Match between system and real world
3	Aesthetic and Minimalist design
4	Learnability
5	Recognition rather than Recall
6	Navigation, organization and structure
7	Error Prevention
8	Flexibility and efficiency of use
9	Help & Documentation
10	Effectiveness & Satisfaction

Each expert evaluator in heuristic usability evaluation closely inspected and examined the interface alone and noted the findings related to the usability issues. MOOC Platforms were thoroughly inspected and evaluated by each expert evaluator and usability issues were noted. The severity of the problem depends on how many times the same issue occurs. The expert evaluators also categorized the issues on the basis of this severity and it's

occurrence on occurrence scale. Depending upon the severity the problems were define as follows

- Cosmetic Problem: the problem is of low severity and there is no need to be fixed
- Minor Usability problem: problem can be fixed on low priority basis
- Major usability problem: high severity problem and needs to be fixed or priority basis
- Usability Catastrophic: Product cannot be released or launched before fixing this issue

The below mentioned table shed light on the issues identified by four expert evaluators who had experience with Coursera earlier.

Table 4.5: Issues identified by Experts

Sr. No.	Heuristics	EVALUATOR 1	EVALUATOR 2	EVALUATOR 3	EVALUATOR 4	Total issues
1	Visibility of system status and contents	3	2	3	2	10
2	Match between system and real world	3	2	2	2	9
3	User Control & Freedom	3	3	2	2	10
4	Consistency & Standards	1	1	2	1	5
5	Error Prevention	3	3	2	3	11

6	Recognition rather than recall	2	3	2	1	8
7	Flexibility and efficiency of use	3	2	3	2	10
8	Aesthetic & Minimalist Design	1	1	1	2	5
9	Help users recognize, diagnose and recover from errors	2	1	1	1	5
10	Help & Documentation	1	1	2	2	6
	Total Issues	22	19	20	18	79
	Percentage	27.8%	24%	25.3%	22.7%	

Table 4.4: Severity of Issues

Sr. No.	**Heuristics**	**COSMETIC**	**MINOR**	**MAJOR**	**CATASTROPHIC**	**Total issues**
1	Visibility of system status and contents	1	1	5	0	7
2	Match between system and real world	2	1	2	0	5
3	User Control & Freedom	1	1	3	0	5
4	Consistency & Standards	0	2	0	0	3

5	Error Prevention	1	0	4	0	5
6	Recognition rather than recall	2	1	0	0	3
7	Flexibility and efficiency of use	1	3	0	0	4
8	Aesthetic & Minimalist Design	0	1	1	0	2
9	Help users recognize, diagnose and recover from errors	0	1	1	0	2
10	Help & Documentation	1	0	0	0	1
	Total Issues	9	11	16	0	37
	Percentage	24.3%	29.7%	43.2%	0%	

4.2 List of all Issues

H1: Visibility of system status

Evaluation:

- The Coursera does not keep the user informed through constructive, appropriate and timely feedback. (Severity 3)
- The presentation arrangement does not assist the user to recognize specific courses by specific terms and course names (Severity 2)

- The buttons are not logically grouped and labelled (Severity 3)
- Navigation is not clear; users don't know where they are and or don't know how to go back to the previous page. (severity 3)
- No appropriate feedback for the uploading process (severity 3)
- After creating or responding to a post, users do not know if their response has actually been sent since there's no message informing users of this action. (severity 2)
- After deleting a post, it is unclear if the post has actually been deleted since there is no confirmation of this action. The post still appears on the page or thread unless the user refreshes. (severity 3)

H2: Match between system and the real world

Evaluation

- Browsing videos with correct profile is difficult (severity 1)
- It is unclear what the code feature is for. Despite making several attempts to edit a code or enter a code, the code feature did not work. (severity 3)
- The coursera does not show similar icons which are familiar with the end users, the chat icon is not designed properly (severity 3)
- It does not use generic words as labels that matches real world (severity 2)
- When we search keyword in coursera search box many time result don't match with the search (severity 1)

H3: **User control and freedom**

Evaluation

- Unable to resume downloading video after pause (severity 3)
- It keeps showing new courses which cannot be skipped unless we click on it (severity 3)
- If a user enters blank or empty spaces in the Title and/or Body, there is no option for the user to delete this post. (severity 3)

- Despite completing a course emails come continuously (severity 1)

H5: **Consistency and standards**

Evaluation

- Typeface and buttons are not styled consistently in pop up windows. (severity 1)
- using different words (“Body” v. “thread description”) to describe the same field may confuse users (severity 1)

H5: **Error prevention**

Evaluation

- Users can insert a broken or invalid link without the system recognizing or preventing this from happening. (severity 3)
- Empty spaces are recognized as words/characters. Users can simply enter only empty spaces in the Title or Body and post this without seeing an error message. (severity 3)
- When a user enters one character as the title, an error message comes up prompting the user to enter a longer title. However, this error message does not specify how long the title should be. (severity 1)
- The character limit for the body of a new thread or a response is 10000, but users do not see this information until they exceed the limit. (severity 3)
- When uploading the image, the user still can use the toolbar and the uploading is cancelled. (severity 3)

H6: Recognition rather than recall

Evaluation

- Unclear functionality on the SUBFORUM menu. (severity 2)

- When the discussion thread is too long and the reply input box is below the fold, the user needs to scroll up and down to look up the original post. (severity 1)
- Users took a long time to complete replying because the reply area was at the bottom of a long page and users cannot read the post and type their feedback at the same time. (severity 1)

H7: **Flexibility and efficiency of use**

Evaluation

- Multiple images cannot be uploaded at the same time. Users have to wait for one image to upload first, before uploading the others. (severity 2)
- It can be difficult to navigate posts by other students/instructors in any thread since some of these posts are lengthy or have images attached that take a lot of space. (severity 1)
- Not easy and no shortcut to to look up a user's own post. (severity 2)
- excessive scrolling needed to find items from one single page (severity

H8: **Aesthetic and minimalist design**

Evaluation

- Navigation is sometimes difficult due to excessive information on Page (severity 3)
- The information is not in the fixed location and format. (severity 2)

H9: **Help users recognize, diagnose, and recover from errors**

Evaluation

- There is no appropriate mechanism to recover or diagnose errors (severity 2)

- When uploading the image, the user still can use the toolbar and the uploading is cancelled. (severity 3)

H10: **Help and documentation**

Evaluation

- There is no proper documentation that specifies details about course completion (severity 1)
- Help documentation is missing for some of the features (severity 1)

4.3 List of Major Iasues Identified by Experts:

H1: Visibility of system status

Evaluation:

- The Coursera does not keep the user informed through constructive, appropriate and timely feedback. **(Severity 3)**
- The buttons are not logically grouped and labelled (Severity 3)
- Navigation is not clear; users don't know where they are and or don't know how to go back to the previous page. (severity 3)
- No appropriate feedback for the uploading process (severity 3)
- After deleting a post, it is unclear if the post has actually been deleted since there is no confirmation of this action. The post still appears on the page or thread unless the user refreshes. (severity 3)

H2: Match between system and the real world

Evaluation

- It is unclear what the code feature is for. Despite making several attempts to edit a code or enter a code, the code feature did not work. (severity 3)
- The coursera does not show similar icons which are familiar with the end users, the chat icon is not designed properly (severity 3)

H3: **User control and freedom**

Evaluation

- Unable to resume downloading video after pause (severity 3)
- It keeps showing new courses which cannot be skipped unless we click on it (severity 3)
- If a user enters blank or empty spaces in the Title and/or Body, there is no option for the user to delete this post. (severity 3)

H5: **Consistency and standards**

Evaluation

No major issue identified.

H5: **Error prevention**

Evaluation

- Users can insert a broken or invalid link without the system recognizing or preventing this from happening. (severity 3)
- Empty spaces are recognized as words/characters. Users can simply enter only empty spaces in the Title or Body and post this without seeing an error message. (severity 3)
- The character limit for the body of a new thread or a response is 10000, but users do not see this information until they exceed the limit. (severity 3)

- When uploading the image, the user still can use the toolbar and the uploading is cancelled. (severity 3)

H6: Recognition rather than recall

Evaluation

No major Issue identified.

H7: **Flexibility and efficiency of use**

Evaluation

No major issue identified.

H8: **Aesthetic and minimalist design**

Evaluation

- Navigation is sometimes difficult due to excessive information on Page (severity 3)

H9: **Help users recognize, diagnose, and recover from errors**

Evaluation

- When uploading the image, the user still can use the toolbar and the uploading is cancelled. (severity 3)

H10: **Help and documentation**

Evaluation

No major issue identified.

4.4 Heuristic Issues with the Highest Number of Major Problems

H1: Visibility of system status (5 Issues)

- The Coursera does not keep the user informed through constructive, appropriate and timely feedback. **(Severity 3)**
- The buttons are not logically grouped and labelled (Severity 3)
- Navigation is not clear; users don't know where they are and or don't know how to go back to the previous page. (severity 3)
- No appropriate feedback for the uploading process (severity 3)
- After deleting a post, it is unclear if the post has actually been deleted since there is no confirmation of this action. The post still appears on the page or thread unless the user refreshes. (severity 3)

H3: **User control and freedom** (3 Issues)

Evaluation

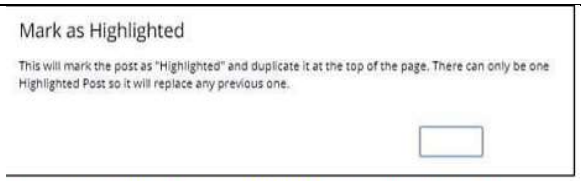
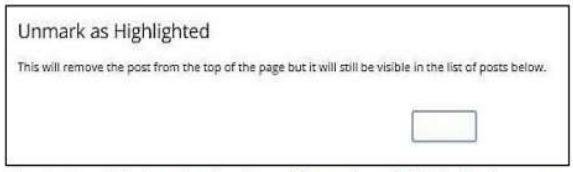
- Unable to resume downloading video after pause (severity 3)
- It keeps showing new courses which cannot be skipped unless we click on it (severity 3)
- If a user enters blank or empty spaces in the Title and/or Body, there is no option for the user to delete this post. (severity 3)

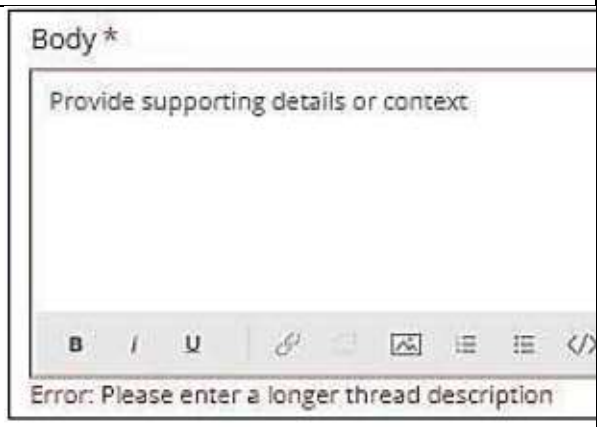
H5: **Error prevention** (4 Issues)

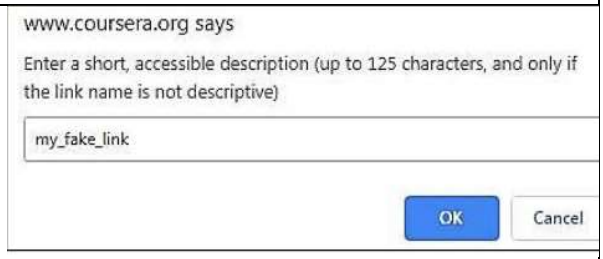
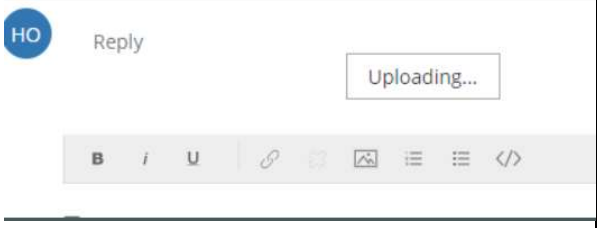
- Users can insert a broken or invalid link without the system recognizing or preventing this from happening. (severity 3)

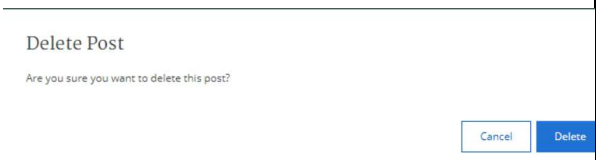
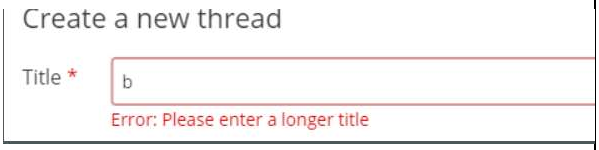
- Empty spaces are recognized as words/characters. Users can simply enter only empty spaces in the Title or Body and post this without seeing an error message. (severity 3)
- The character limit for the body of a new thread or a response is 10000, but users do not see this information until they exceed the limit. (severity
- When uploading the image, the user still can use the toolbar and the uploading is cancelled. (severity 3)

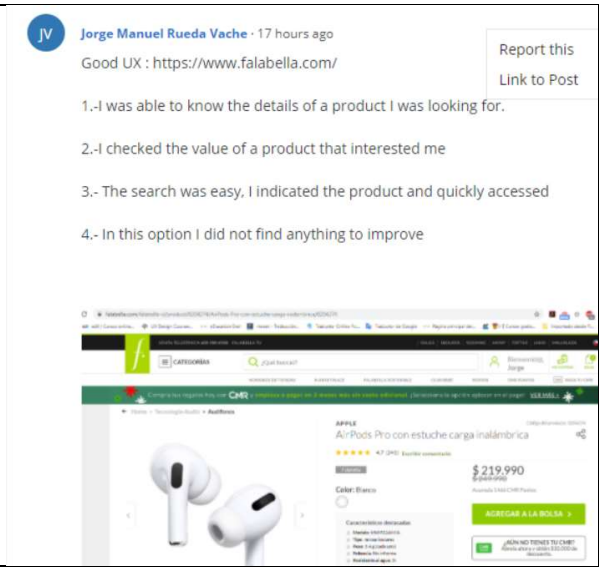
Table 4.5 : Heuristic Evaluation Finding with Recommendation

Sr.	Issue/Recommendation	Scree n
1	Visibility of the system status Issue: there are missing button labels on three pop-up confirmation screens: the screens about marking or unmarking a post as highlighted, and the screen about deleting a reply to a post. Recommendation: Add the title on the top bar.	 Fig: Button labels missing from Mark as Highlighted screen.  Fig: Button labels missing from Unmark as Highlighted screen.  Fig: Button label missing from Delete Post screen for a reply.

2	User Control and Freedom Issue: In Coursera's discussion forums, edits to a thread or to a reply to a thread cannot be undone, once they have been submitted. Recommendation: Make it easy to undo edits, by including a way to go back to a previous version of a post.	
3	Error Prevention Issue: In the Coursera discussion forums, the image upload process for posts (creating new threads and new replies, and editing threads and replies) allows users to select nonimage file types. Recommendation: Only allow selection of acceptable file types, check that the selected file is one of the acceptable file types, and if it is not, ask for a new file selection.	
4	Consistency and Standard: The Coursera discussion forums require that posts and replies to a post contain body text, but the error message refers to a "thread description", not to the body field. Recommendation: Call the field by the same name in both the field label and in the error message, so change the error message to "Please fill out the body of the thread with a longer description."	

	Error Prevention Issue: When creating or editing a thread or a reply to a thread, Coursera's discussion forums allow users to insert faulty links into their posts. Recommendation: Include a function to test the link.	
	Visibility of System Status Issue: users are prompted to add a description when adding a link to the body of a post. However, this description is not visible. Instead, the whole link appears in the body of the post Recommendation: Link descriptions should (always) appear in the body of posts	
	Visibility of System Status Issue: It takes up to a minute, sometimes more, for users to upload an image. Larger files take even longer. This process is not only time-consuming, appropriate feedback on how much time it will take for the image to finish processing is not provided. Recommendation: Make the image upload process faster. For larger images, provide a time estimate that shows when the image will complete upload and allow users to use other functions while the image is uploading.	

	Help users recognize, diagnose, and recover from errors Issue: After deleting a post, it is unclear if the post has actually been deleted since there is no confirmation of this action. The post still appears on the page or thread unless the user refreshes. Recommendation: Provide a pop-up message letting users know their response has been deleted and ensure that the post does not appear on the page anymore.	
	Error Prevention Issue: When a user enters one character as the title, an error message comes up prompting the user to enter a longer title. However, this error message does not specify how long the title should be. Recommendation Ensure that the error message mentions the number of characters required for a title or include a message before users type, such as "enter at least two characters" so this error can be prevented before it actually occurs. By providing a character limit before the user enters information, such an error could be prevented.	
	User control and freedom Issue: If a user enters blank or empty spaces in the Title and/or Body, there is no option for the user to delete this post. RecommendationEnsure that users can delete a post with at least a Title or any post they create	

	Flexibility and efficiency of use Issue: It can be difficult to navigate posts by other students/instructors in any thread since some of these posts are lengthy or have images attached that take a lot of space. Recommendation: There should be an option to minimize posts so only the first few sentences show. This will make it easier for users to navigate through them.	

4.5. Conclusion

The issues have been identified by the Experts. There is no framework to effectively rank and prioritize the issues provided by the Heuristic Evaluation. Therefor in the next chapter we will integrate effective decision making criteria to prioritize the main issues and sub issues.

CHAPTER 5

RESULTS AND DISCUSSIONS

This chapter illustrates the findings of this study. Data analysis, final results and finding which are obtained after applying the heuristic evaluation method and AHP. For the calculations of AHP results, MS Excel is used.

5.1 Analytical Hierarchy Process (AHP)

This phase presents the findings by the AHP process and results and findings will be discussed in this chapter.

Step 1

In this round, 8 experts were selected as experts of MOOC Platforms and they were chosen in the first round of the AHP. They participated in this research study voluntarily with consent. The demographic information of the experts is given in the below Table 5.1:

Table 5.1: AHP Experts Demographic Information

Sr. No.	Gender	Name	Designation	Education	Experience with MOOC Platforms (particularly Coursera)
1	M	Shahid Rasul	Computer Lecturer/ Online Courses Trainer	MS CS	7 years
2	F	Iram Maqsood	Online Course Instructor/Trainer / IT instructor at Beaconhouse	MS CS	3 years
3	M	Irfan Haider	Front end Developer/ Graphic Designer	MS CS	6 years
4	F	Zoyya Khalid	IT/ICT instructor at Beaconhouse	BS CS	2 years
5	M	Shahzaib	Web developer/IT Lab Instructor	MIT	4 years
6	M	Zeeshan Khalid	UX/UI Fron end developer/ Instructor at Aitchison College	MIT	6 years
7	M	Hassam Hassan	Software Project Manager	BS IT	2 years
8	M	Muhammad Ijaz	Online Course Instructor/ We Developer	MBIT	3 years

All these experts were asked to fill the questionnaire form which was sent to them through their emails. All the participants filled the form and mail back the forms. The form comprises all the important information which is required to fill the form and contact was also given in case of any query from participants. The questionnaire form will be found in Appendix B .

The AHP hierarchy consists of three main criteria and every criterion having a few sub-criteria. The participants were asked to choose the pairwise comparison. By using the questionnaire, the participants compare the relative importance of the decision alternatives of pairwise concerning criteria and the goal explained below in Figure 5.1. Each participant is requested to enter his/her judgments and makes a distinct, identifiable contribution to the issue. Participants do not have to agree on the relative importance of the criteria or the rankings of the alternatives. As shown in Figure 5.1, the first level of the hierarchy is the ultimate goal of the project; the second level represents the criteria based on which the projects are to be evaluated, the third level represents the sub-criteria.

The Heuristics with maximum number of major issues identified were choses as the Main Criteria and the issues under each of those heuristics were selected as the sub criteria which helped in forming the AHP Hierarchy as shown in the figure 5.1.

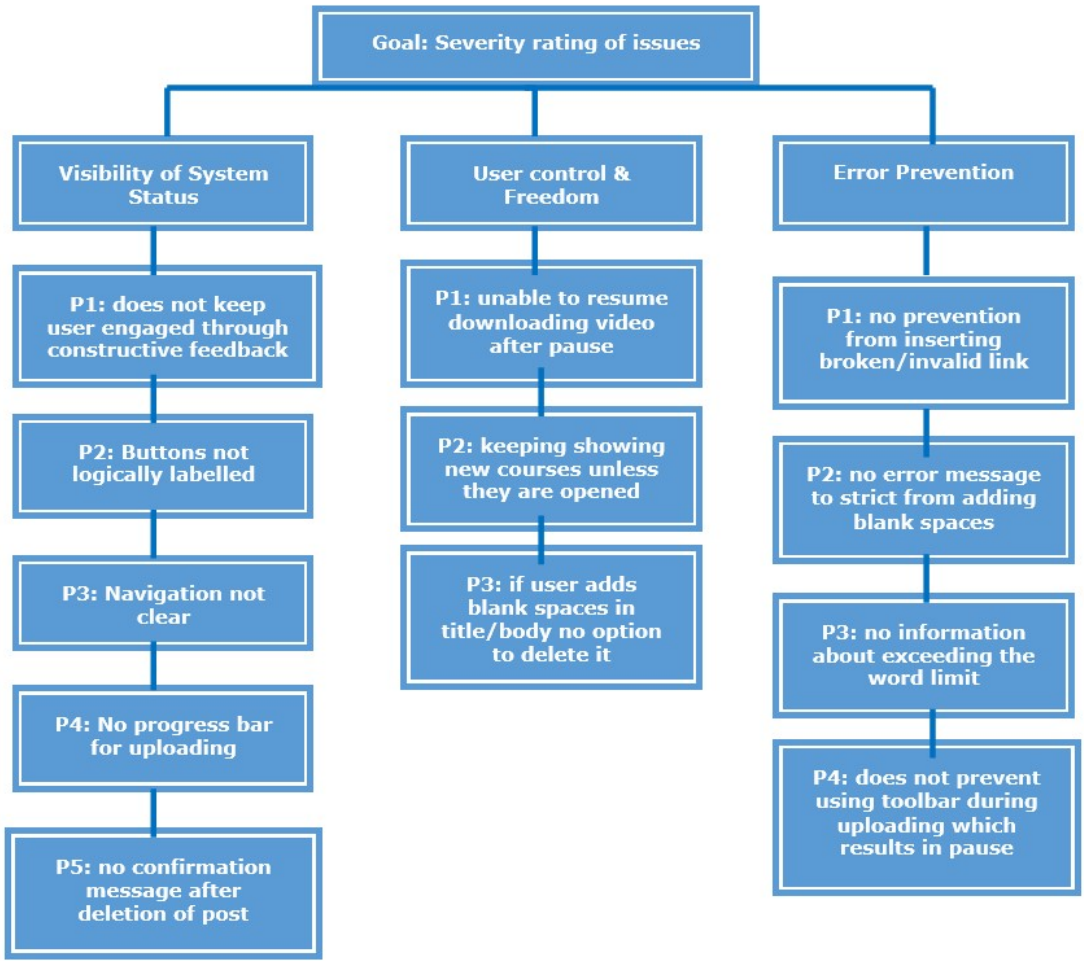


Figure 5.1 AHP Hierarchy

The pairwise comparison scale is used to express the importance of one element over another (Table 5.2).

Table 5.2: Satty's Relative Importance Scale

Explanation	Numeric Values
If Option A and Option B are equally important: select →	1
If Option A is moderately more important than Option B: select →	3
If Option A is strongly more important than Option B: select →	5
If Option A is very strongly more important than Option B: select →	7
If Option A is extremely more important than Option B: select →	9

The scale of 2,4,6,8 was overlooked in the questionnaire and pairwise comparison because these values are the mediator which does not affect the overall results. In this survey total of ten participants were chosen and after calculations, the final data of six participants were considered because for the other five participants the consistency ratio was not in the range as per satty's suggestion.

The final results with each step are discussed further below.

Step 2:

After gathering data from all the participants AHP was applied to the data to calculate the final results. The AHP hierarchy is defined in step 1 and this round will discuss the next phase of AHP.

5.2 Formulating Pairwise Comparison Matrices for each participant

This step will show all the pairwise comparison matrices of all the participants. The participants were asked to compare each hierarchy level (main criteria and sub-criteria) by giving the relative score which is defined by satyy and is described in phase 1. The main factors and sub-criteria were assigned values by five participants. The below tables shows the values assigned to the main criteria and sub-criteria:

Table 5.3: Decision matrix of main dimensions from each expert

	FACTORS	**Visibility of System Status**	**User Control & Freedom**	**Error Prevention**
First Decision maker	**Visibility of System Status**	1	9	5
	User Control & Freedom	1/9	1	1/3
	Error Prevention	1/5	3	1
Second Decision maker	**FACTORS**	**Visibility of System Status**	**User Control & Freedom**	**Error Prevention**
	Visibility of System Status	1	1/5	1/7
	User Control & Freedom	5	1	1/3
	Error Prevention	7	3	1
	FACTORS	**Visibility of System Status**	**User Control & Freedom**	**Error Prevention**

Third Decision maker	**Visibility of System Status**	1	1	3
	User Control & Freedom	1	1	5
	Error Prevention	1/3	1/5	1
Fourth Decision maker	**FACTORS**	**Visibility of System Status**	**User Control & Freedom**	**Error Prevention**
	Visibility of System Status	1	3	1
	User Control & Freedom	1/3	1	5
	Error Prevention	1	1/5	1
Fifth Decision maker	**FACTORS**	**Visibility of System Status**	**User Control & Freedom**	**Error Prevention**
	Visibility of System Status	1	5	3
	User Control & Freedom	1/5	1	1
	Error Prevention	1/3	1	1
	FACTORS	**Visibility of System Status**	**User Control & Freedom**	**Error Prevention**
	Visibility of System Status	1	1	1

Sixth Decision maker	**User Control & Freedom**	1	1	1
	Error Prevention	1	1	1
Seventh Decision maker	**FACTORS**	**Visibility of System Status**	**User Control & Freedom**	**Error Prevention**
	Visibility of System Status	1	1/3	1/9
	User Control & Freedom	3	1	1/5
	Error Prevention	9	5	1
Eigth Decision maker	**FACTORS**	**Visibility of System Status**	**User Control & Freedom**	**Error Prevention**
	Visibility of System Status	1	3	1
	User Control & Freedom	1/3	1	5
	Error Prevention	1	1/5	5

Table 5.4: Decision matrix of first criteria's (Visibility of System Status) sub-criteria from each expert.

First Decision maker	**SUB-FACTORS**	**Constructive feedback**	**logically labelled button**	**Clear navigation**	**Uploading progress bar**	**confirmation after deletion**
	Constructive feedback	1	1	1	3	9
	logically labelled button	1	1	1	1	7
	Clear navigation	1	1	1	5	7
	Uploading progress bar	1/3	1	1/5	1	3
	Confirmation after deletion	1/9	1/7	1/7	1/3	1
Second Decision maker	**SUB-FACTORS**	**Constructive feedback**	**logically labelled button**	**Clear navigation**	**Uploading progress bar**	**confirmation after deletion**
	Constructive feedback	1	1	3	1/3	1
	logically labelled button	1	1	3	1	3
	Clear navigation	1/3	1/3	1	1/5	1
	Uploading progress bar	3	1	5	1	3
	Confirmation after deletion	1	1/3	1	1/3	1

Third Decision maker	**SUB-FACTORS**	**Constructive feedback**	**logically labelled button**	**Clear navigation**	**Uploading progress bar**	**confirmation after deletion**
	Constructive feedback	1	1	1/9	1/3	1
	logically labelled button	1	1	1/5	1	1
	Clear navigation	9	5	1	5	5
	Uploading progress bar	3	1	1/5	1	1
	Confirmation after deletion	1	1	1/5	1	1
Fourth Decision maker	**SUB-FACTORS**	**Constructive feedback**	**logically labelled button**	**Clear navigation**	**Uploading progress bar**	**confirmation after deletion**
	Constructive feedback	1	1	9	9	9
	logically labelled button	1	1	9	9	9
	Clear navigation	1/9	1/9	1	1/3	1
	Uploading progress bar	1/9	1/9	3	1	1
	Confirmation after deletion	1/9	1/9	1	1	1
	SUB-FACTORS	**Constructive feedback**	**logically labelled button**	**Clear navigation**	**Uploading progress bar**	**confirmation after deletion**

Fifth Decision maker	**Constructive feedback**	1	1	1/9	1/7	1/5
	logically labelled button	1	1	1/5	1/7	1/9
	Clear navigation	9	5	1	1/3	1
	Uploading progress bar	7	7	3	1	1
	Confirmation after deletion	5	9	1	1	1
Sixth Decision maker	**SUB-FACTORS**	**Constructive feedback**	**logically labelled button**	**Clear navigation**	**Uploading progress bar**	**confirmation after deletion**
	Constructive feedback	1	1	1	1	1
	logically labelled button	1	1	1	1	1
	Clear navigation	1	1	1	1	1
	Uploading progress bar	1	1	1	1	1
	Confirmation after deletion	1	1	1	1	1
Seventh Decision maker	**SUB-FACTORS**	**Constructive feedback**	**logically labelled button**	**Clear navigation**	**Uploading progress bar**	**confirmation after deletion**
	Constructive feedback	1	1/3	1/9	1/7	1/9

	logically labelled button	3	1	1	1	1/7
	Clear navigation	9	1	1	1	1/5
	Uploading progress bar	7	1	1	1	1/9
	Confirmation after deletion	9	7	5	9	1
	SUB-FACTORS	**Constructive feedback**	**logically labelled button**	**Clear navigation**	**Uploading progress bar**	**confirmation after deletion**
	Constructive feedback	1	1	9	3	9
	logically labelled button	1	1	3	1	5
Eigth Decision maker	**Clear navigation**	1/9	1/3	1	1/3	1
	Uploading progress bar	1/3	1	1	1	3
	Confirmation after deletion	1/9	1/5	1	1/3	1

Table 5.5: Decision matrix of second criteria's (User Control and freedom) sub-criteria from each expert

	SUB-FACTORS	**Resume downloading**	**Control pop ups of courses**	**Delete blank spaces**
	Resume downloading	1	9	3

First Decision maker	**Control pop ups of courses**	1/9	1	1/5
	Delete blank spaces	1/3	5	1
Second Decision maker	**SUB-FACTORS**	**Resume downloading**	**Control pop ups of courses**	**Delete blank spaces**
	Resume downloading	1	9	1
	Control pop ups of courses	1/9	1	1/5
	Delete blank spaces	1	5	1
Third Decision maker	**SUB-FACTORS**	**Resume downloading**	**Control pop ups of courses**	**Delete blank spaces**
	Resume downloading	1	5	1
	Control pop ups of courses	1/5	1	1/7
	Delete blank spaces	1	7	1
Fourth Decision maker	**SUB-FACTORS**	**Resume downloading**	**Control pop ups of courses**	**Delete blank spaces**
	Resume downloading	1	1/5	1/3
	Control pop ups of courses	5	1	1

	Delete blank spaces	3	1	1
Fifth Decision maker	**SUB-FACTORS**	**Resume downloading**	**Control pop ups of courses**	**Delete blank spaces**
	Resume downloading	1	5	3
	Control pop ups of courses	1/5	1	1
	Delete blank spaces	1/3	1	1
Sixth Decision maker	**SUB-FACTORS**	**Resume downloading**	**Control pop ups of courses**	**Delete blank spaces**
	Resume downloading	1	1	1
	Control pop ups of courses	1	1	1
	Delete blank spaces	1	1	1
Seventh Decision maker	**SUB-FACTORS**	**Resume downloading**	**Control pop ups of courses**	**Delete blank spaces**
	Resume downloading	1	3	1
	Control pop ups of courses	1/3	1	5
	Delete blank spaces	1	1/5	5

	SUB-FACTORS	Resume downloading	Control pop ups of courses	Delete blank spaces
Eigth Decision maker	**Resume downloading**	1	3	1
	Control pop ups of courses	1/3	1	5
	Delete blank spaces	1	1/5	1

Table 5.6: Decision matrix of third criteria's (Error Prevention) sub-criteria from each expert

	SUB-FACTORS	Invalid link prevention	prevent blank spaces	Invalid links	Halts downloading
First Decision maker	**Invalid link prevention**	1	9	9	3
	prevent blank spaces	1/9	1	1	1/5
	Invalid links	1/9	1	1	1/5
	Halts downloading	1/3	5	5	1
	SUB-FACTORS	**Invalid link prevention**	**prevent blank spaces**	**Invalid links**	**Halts downloading**

Second Decision maker	**Invalid link prevention**	1	9	9	5
	prevent blank spaces	1/9	1	1	1/5
	Invalid links	1/9	1	1	1/5
	Halts downloading	1/5	5	5	1
Third Decision maker	**SUB-FACTORS**	**Invalid link prevention**	**prevent blank spaces**	**Invalid links**	**Halts downloading**
	Invalid link prevention	1	3	5	7
	prevent blank spaces	1/3	1	3	7
	Invalid links	1/5	1/3	1	5
	Halts downloading	1/7	1/7	1/5	1
Fourth Decision maker	**SUB-FACTORS**	**Invalid link prevention**	**prevent blank spaces**	**Invalid links**	**Halts downloading**
	Invalid link prevention	1	3	5	9
	prevent blank spaces	1/3	1	3	9
	Invalid links	1/5	1/3	1	5
	Halts downloading	1/9	1/9	1/5	1

Fifth Decision maker	**SUB-FACTORS**	**Invalid link prevention**	**prevent blank spaces**	**Invalid links**	**Halts downloading**
	Invalid link prevention	1	1	1	1
	prevent blank spaces	1	1	1	1
	Invalid links	1	1	1	1
	Halts downloading	1	1	1	1
Sixth Decision maker	**SUB-FACTORS**	**Invalid link prevention**	**prevent blank spaces**	**Invalid links**	**Halts downloading**
	Invalid link prevention	1	1	1/3	1/7
	prevent blank spaces	1	1	1	1/7
	Invalid links	3	1	1	1/5
	Halts downloading	7	7	5	1
Seventh Decision maker	**SUB-FACTORS**	**Invalid link prevention**	**prevent blank spaces**	**Invalid links**	**Halts downloading**
	Invalid link prevention	1	5	9	9

	prevent blank spaces	1/5	1	3	7
	Invalid links	1/9	1/3	1	3
	Halts downloading	1/9	1/7	1/3	1
Eigth Decision maker	**SUB-FACTORS**	**Invalid link prevention**	**prevent blank spaces**	**Invalid links**	**Halts downloading**
	Invalid link prevention	1	1	5	7
	prevent blank spaces	1	1	5	7
	Invalid links	1/5	1/5	1	5
	Halts downloading	1/7	1/7	1/5	1

5.3 Normalized Eigen Vector and Criteria Weights

In the wake of framing the pairwise comparison matrices, the following stage is to figure a normalized eigenvector which shows the general commitment of one component over the other. The criteria and sub- criteria weights are determined by testing the consistency ratio of every member's data. Testing the consistency ratio (CR) of the participant's data while computing the criteria weights is vital in AHP. The below tables show the priority weights of the main criteria as given by every participant, where CI alludes to the consistency index, RI is the random consistency, λmax is the greatest eigenvalue and CR consistency ratio which is acceptable.

Table 5.7 Priority weight and consistency check of main factors/criteria by each expert

Criteria	PW of the first expert	PW of the second expert	PW of the third expert	PW of the fourth expert	PW of the fifth expert	PW of the sixth expert	PW of the seventh expert	PW of the eigth expert
Visibility of System Status	0.75	0.17	0.41	0.43	0.66	0.33	0.07	0.41
User control & freedom	0.07	0.26	0.48	0.36	0.16	0.33	0.18	0.28
Error Prevention	0.18	0.57	0.11	0.21	0.19	0.33	0.75	0.31

Table 5.7: Priority weight &Consistency check of first criteria's (visibility of system status) sub-criteria by each expert

Criteria	PW of the first expert	PW of the second expert	PW of the third expert	PW of the fourth expert	PW of the fifth expert	PW of the sixth expert	PW of the seventh expert	PW of the eigthexpert
P1	0.29	0.18	0.08	0.42	0.04	0.20	0.03	0.44
P2	0.24	0.27	0.11	0.42	0.04	0.20	0.10	0.26
P3	0.31	0.08	0.58	0.04	0.25	0.20	0.15	0.06
P4	0.12	0.36	0.13	0.06	0.37	0.20	0.12	0.18
P5	0.04	0.11	0.11	0.05	0.30	0.20	0.60	0.05

Table 5.9: Priority weight &Consistency check of Second criteria's (user control & freedom) sub-criteria by each expert

Criteria	PW of the first expert	PW of the second expert	PW of the third expert	PW of the fourth expert	PW of the fifth expert	PW of the sixth expert	PW of the seventh expert	PW of the eigthexpert
P1	0.67	0.51	0.44	0.11	0.66	0.33	0.43	0.43
P2	0.06	0.07	0.08	0.48	0.16	0.33	0.36	0.36
P3	0.27	0.42	0.49	0.41	0.19	0.33	0.21	0.21

Table 5.10: Priority weight &Consistency check of third criteria's (error prevention) sub-criteria by each expert

Criteria	PW of the first expert	PW of the second expert	PW of the third expert	PW of the fourth expert	PW of the fifth expert	PW of the sixth expert	PW of the seventh expert	PW of the eigthexpert
P1	0.61	0.65	0.54	0.55	0.25	0.08	0.65	0.41
P2	0.06	0.06	0.27	0.28	0.25	0.10	0.22	0.41
P3	0.06	0.06	0.14	0.13	0.25	0.16	0.09	0.13
P4	0.27	0.23	0.05	0.04	0.25	0.66	0.04	0.05

In this progression of AHP, the various qualities which were given by expert participants are integrated into a single matrix. The mean method is applied to work out every one of the resultant values of every criterion and sub-criteria.

5.4 Ranking the factors based on priority weights

The last step of Round 2 incorporates the positioning of criteria and sub-criteria dependent on their priority weights. These weights were then parted into "local weights " and "global weights ". Local weights allude to the priority weights concerning the first progressive level, while "global weights " are the priority weights concerning the highest hierarchical level, which demonstrates the goal.

To lead an overall ranking of the sub-classes, AHP consolidates the priority weights of the measurement with the comparison ratings for factor to track down the local and global ranking [80]. This is performed by the following equation:

Global weights=∑ (Local weight for dimension i x local weight for factor j concerning dimension i).

The below Table shows the overall local and global rankings of the main criteria and sub-criteria

Table 5.10: Local and Global Rankings of Criteria and Sub-Criteria

Main Problems	Priority weight with contribution %	Sub-Problems	Local weightage with contribution %	Local Rank	Global weightage with contribution %	Global Rank
Visibity of System Status	0.403	P1	0.211	1	0.0851	1
		P2	0.204	3	0.0824	3
		P3	0.209	2	0.0841	2
		P4	0.195	4	0.0786	4
		P5	0.181	5	0.0728	5
User Control and Freedom	0.265	P1	0.447	1	0.1185	7
		P2	0.239	3	0.0633	11
		P3	0.314	2	0.0832	8
Error Prevention	0.332	P1	0.469	1	0.1557	6
		P2	0.207	2	0.0688	9
		P3	0.126	4	0.0418	12
		P4	0.198	3	0.0657	10

With the Help of AHP the issues identified by the Experts in Heuristic Evaluation have been prioritized. HE helps to identify problems but lacks the effective decision making criteria to rank the main heuristics and sub issues. By integrating AHP into step three of the Heuristic Evaluation Process the ranking of the factors and subfactors have been prioritized.

5.6 Framework for improving the severity ranking osf issues

Based on the results obtained from the AHP, the framework is created. The framework is displayed in Figure 5.2 below:

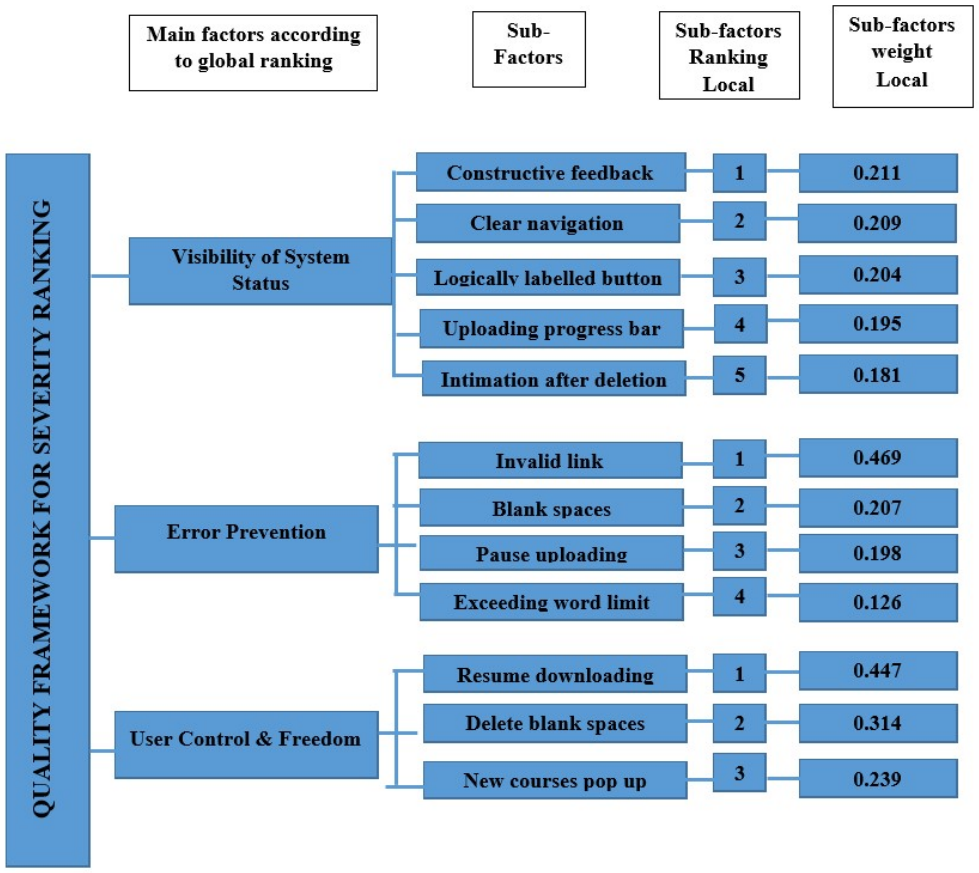


Figure 5.2 Framework for severity ranking

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1. Conclusion

The leading objective of this thesis was to enhance the usability evaluation process by integrating SHP into Heauristic Evaluation Technique. Initially literature review was done in order to gain insight knowledge about the usability evaluation methods and to find related research work. In the second step, the author selected four expert and heuristic evaluation was carried out. With the help of the case study the Heuristic Techniques was comprehensively studies and its limitations were identified. Heuristic Evaluation helped in identifying the issues but its step three related to severity ranking does not offer effective decision making criteria. After identifying the major issues effective decion making criteria in the form of MCD Multicriteria Decsion making tool AHP was integrated. 8 experts were selected to help in recording the responses. The results gathered were further decomposed and both individually and in a combined way their aggregated result helped in prioritizing them most important factors.

6.2. Future Work

This research is not without limitations. The research selection is biased in terms of both computer literacy and education. In particular, the participants who were recruited at random were rather tech-savvy and highly educated. Thus, the results of the study may not be generalizable to learners with poor computer literacy or training. A combination of two or more MCDA Techniques can be incorporated into Heuristic to further improve severity ranking of Heuristic.

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APPENDIX A
HEURISTIC EVALUATION FORM

Bahria University Lahore Campus

Consent Form for Participation in Masters Research

Key Information About The Researchers And This Study

Title of Research: Integrating AHP into heuristic evaluation to improve usability evaluation Process

Student Name: Anam Abrar **Contact**: 03324871553

You are welcome to join this research study and this form will help you to decide whether you want to join this study or not. Taking part in this research study is voluntary. You can decide not to take part in this research study and can stop at any time. Please take your valuable time to read this form and decide whether you want to participate in this research study or not.

Purpose of This Study

The main purpose of this study to evaluate the usability of MOOC Platform so that we can develop a framework through which we can assess the quality of MOOC Platform. In this research study, we are performing the heuristic evaluation of the MOOC Platform through experts so that we can identify the existing issues in the MOOC Platform and provide a framework based on the issue. The heuristic evaluation is performed by expert users. You are participating in this study as an expert evaluator to evaluate the MOOC Platform. The heuristic evaluation will be performed according to the Jakob Nielsen heuristics. Ten heuristics will be evaluated and are explained on Page three to onwards of the document. The usability issues which are identified then will be prioritized through some MCDA method. The usability framework will be created. After the development of

the framework, it will be validated. The results will help to determine the usability of MOOC Platform.

Your Consent

By signing this document, you are agreeing to be in this study. Make sure you understand what the study is about before you sign. If you have any questions about the study after you sign this document, you can contact the study team using the information above.

I understand what the study is about and my questions so far have been answered. I agree to take part in this study.

Print Legal Name: _____

Signature: _____

Date of Signature (mm/dd/yy): _____

Demographic Information:

This study will also collect your demographic information so that we can use it in our study but this your name and personal information will not be shared with anyone.

Name		**Email**	
Age		**Teacher/Student**	
Gender		**Professional Role**	
Education Level		**MOOC Using Experience**	

Heuristic Evaluation

Before starting the evaluation, there are some points which are needed to be explained. You have to evaluate the MOOC Platform according to the heuristics as well as give the issues severity rating. You are required to rate the severity of the usability issue ranging from 0 to 4. These severity ratings according to each range are explained below:

0 = I don't agree that this is a usability problem at all.

1= Cosmetic problem only: need not to be fixed unless extra time is available on the project.

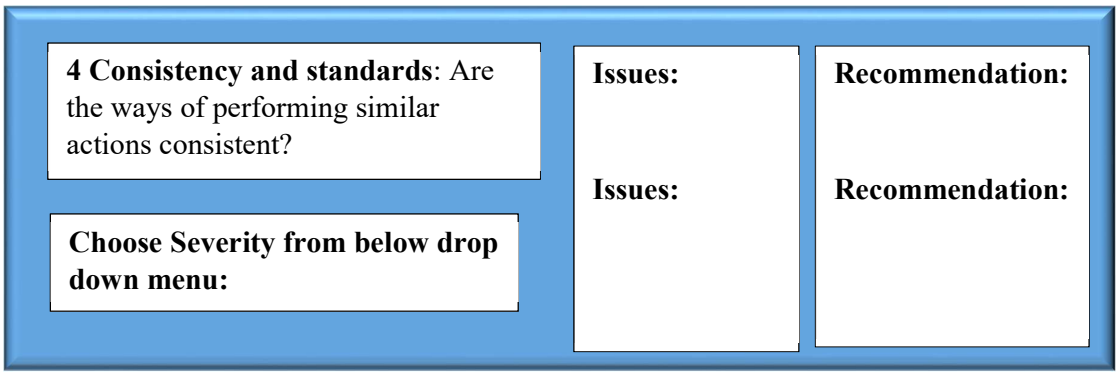
2= Minor Usability Problem: fixing this should be given low priority.

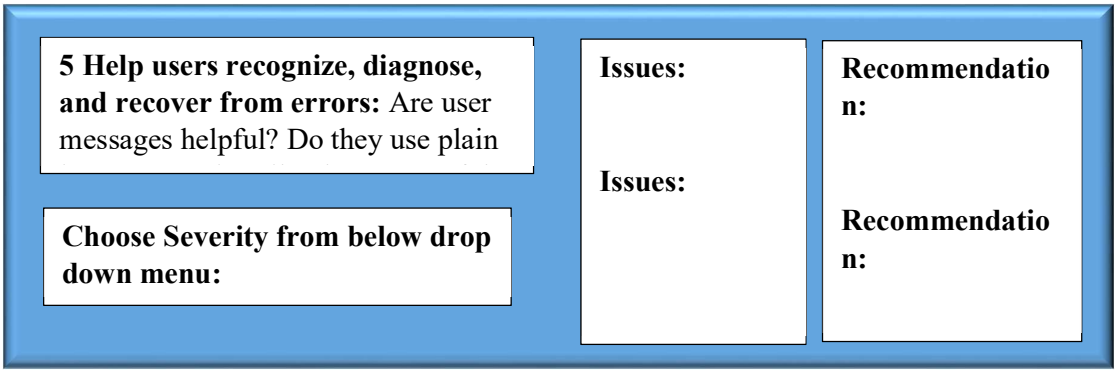
3= Major Usability Problem: important to fix, so should be given high priority.

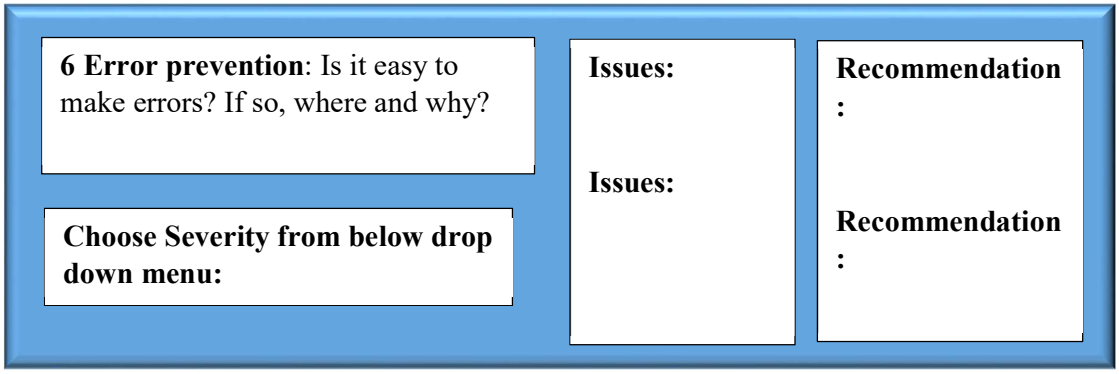
4= Usability Catastrophe: imperative to fix this before the product can be released.

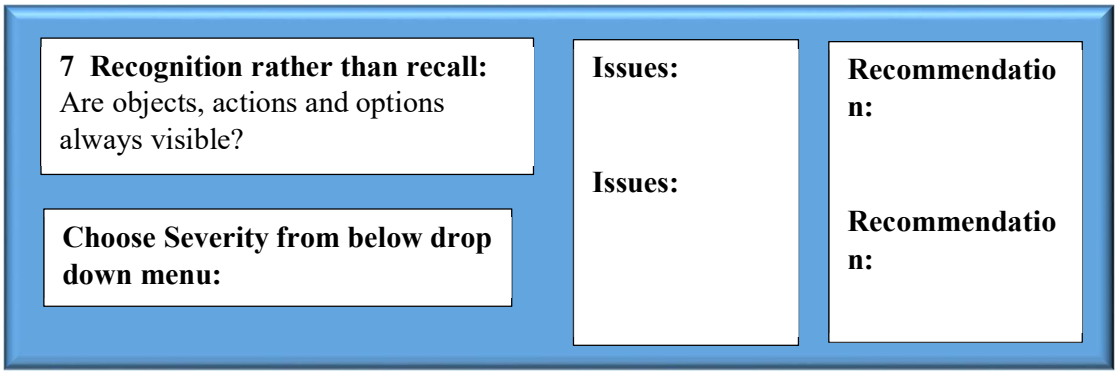
Heuristic Evaluation Sheet

1 Visibility of System Status: It means that system should always keep users informed what is going during the usage and will give appropriate feedback in appropriate time. **Choose Severity from below drop down menu:**	**Issues:** **Issues:**	**Recommendation:** **Recommendation:**
2 Match between the system and real world: Is the language used at the interface simple? Are the words, phrases and concepts used familiar to **Choose Severity from below drop down menu:**	**Issues:** **Issues:**	**Recommendation:** **Recommendation:**
3 User control and freedom: Are there ways of allowing users to easily escape from places they **Choose Severity from below drop down menu:**	**Issues:** **Issues:**	**Recommendation:** **Recommendation:**


4 Consistency and standards: Are the ways of performing similar actions consistent?
Choose Severity from below drop down menu:
Issues:
Issues:
Recommendation:
Recommendation:


5 Help users recognize, diagnose, and recover from errors: Are user messages helpful? Do they use plain
Choose Severity from below drop down menu:
Issues:
Issues:
Recommendation:
Recommendation:


6 Error prevention: Is it easy to make errors? If so, where and why?
Choose Severity from below drop down menu:
Issues:
Issues:
Recommendation:
Recommendation:


7 Recognition rather than recall: Are objects, actions and options always visible?
Choose Severity from below drop down menu:
Issues:
Issues:
Recommendation:
Recommendation:

8 Flexibility and efficiency of use: Have accelerators (i.e. shortcuts) been provided that allow more experience users to carry out tasks **Choose Severity from below drop down menu:**	**Issues:** **Issues:**	**Recommendation:** **Recommendation:**

9 Aesthetic and minimalist design: Is any unnecessary and irrelevant information provided? **Choose Severity from below drop down menu:**	**Issues:** **Issues:**	**Recommendation:** **Recommendation:**

10 Help and documentation: Is help information provided that can be easily searched and easily **Choose Severity from below drop down menu:**	**Issues:** **Issues:**	**Recommendation:** **Recommendation:**

APPENDIX B

AHP Questionnaire Survey

Integrating AHP into Heuristic Evaluation to enhance usability evaluation Process

Multi-Criteria Analysis For Ranking Usability Factors

Directions: Please answer the below questions carefully.

Participant's Demographic Information

Age

☐ 18-25 ☐ 25-30 ☐ 30-35 ☐ 35 or older

Gender

☐ Male ☐ Female

What is your university name? _____

Highest level of education you have completed _____

Please choose one of the following that best describes your experience of using the Coursera:

☐ Never Use ☐ <1 Year ☐ 1-5 Years ☐ 5-10 years

Introduction

By using the questionnaire, the participants compare the relative importance of the decision alternatives of pairwise concerning criteria and the goal explained below (**Table 1**). Each participant is requested to enter his/her judgments and make a distinct, identifiable contribution to the issue. Participants do not have to agree on the relative importance of the criteria or the rankings of the alternatives. As shown in Table 1, the first level of the hierarchy is the ultimate goal of the project; the second level represents the criteria based on which the projects are to be evaluated, the third level represents the sub-criteria.

Table 1 AHP Hierarchy Structure

Severity Rating of Issues		
Visibility of system status	**User control & freedom**	**Error prevention**
P1: Does not keep user engaged through constructive feedback	P1: Unable to resume downloading video after pause	P1: No prevention from inserting broken/invalid link
P2: Buttons not logically labelled	P2: Keep showing new courses unless they are opened	P2: No error message to restrict from adding blank spaces
P3: Navigation not clear	P3: If blank spaces are added not option to delete post	P3: No information about exceeding the word limit
P4: No progress bar for uploading		P4: Does not prevent from using toolbar during uploading which results in pause
P5: No confirmation message after deletion of post		

Goal: Severity ranking of usability issues

Criteria: Three criteria were chosen for evaluation (Heuristics with highest number of major problems)

In the following sections, I would like to elicit your opinion to select amongst the alternatives. The pairwise comparison scale is used to express the importance of one element over another (Table 2).

Table: 2

Explanation	**Numeric Values**	**Numeric Values (in case of inverse)**
If Option A and Option B are equally important: select →	1	1
If Option A is moderately more important than Option B: select →	3	1/3
If Option A is strongly more important than Option B: select →	5	1/5
If Option A is very strongly more important than Option B: select →	7	1/7
If Option A is extremely more important than Option B: select →	9	1/9

PAIR-WISE COMPARISION MATRIX OF MAIN CRITERIA

Fill the values according to the criteria in Table 1.

CRITERIA	Visibility of system status	User control & freedom	**Error Prevention**
Visibility of system status			
User control & freedom			
Error prevention			

Comparison Matrix for the 1st Criteria (Visibility of System Status) sub-criteria

Sub-criteria	P1: does not keep the user engaged through constructive feedback	P2: buttons are not logically labeled	P3: navigation not clear	P4: no progress bar for uploading	P5: no confirmation message after deletion of post
P1: does not keep user engaged through constructive feedback					
P2: buttons are not logically labelled					
P3: navigation not clear					
P4: no progress bar for uploading					
P5: no confirmation message after deletion of post					

Comparison Matrix for the 2nd Criteria (User Control & Freedom) sub criteria

Sub criteria	P1: unable to resume downloading video after pause	P2: keep showing new courses unless they are opened	P3: if user add blank spaces no option to delete it
P1: unable to resume downloading video after pause			
P2: keep showing new courses unless they are opened			
P3: if user add blank spaces no option to delete it			

Comparison Matrix for the 3rd Criteria (Error Prevention) sub criteria

Sub criteria	P1: no prevention from inserting broken link	P2: no error message from restricting to add blank spaces	P3: no information about exceeding word limit	P4:does not prevent using toolbar while downloading
P1: no prevention from inserting broken link				
P2: no error message from restricting to add blank spaces				
P3: no information about exceeding word limit				
P4:does not prevent using toolbar while downloading				