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GOAL PRIORITIZATION AND PRELIMINARY USABILITY EVALUATION: AN APPROACH TO ASSIST NOVICE DESIGNER

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ABSTRACT

The usability engineering process has indicated the importance of setting usability criteria. In specifying a usability goal, usability attributes or criteria need to be identified in order to achieve this. This paper presents a quantitative basis for selecting and prioritizing usability goals, thereafter selecting the best prototype relative to usability goals. The proposed method consists of two main phases. These are namely: the prioritizing goals phase and the user evaluation phase. Quantitative analysis uses an analytic hierarchy process (AHP) to determine the rank of the goals. The level of importance of usability attributes assists designers to decide which alternative designs meet the most important usability characteristics. This approach appropriate to train the novice designers to bear their collaborative design goals in mind and select the best prototype based on users' quantitative assessment result.

Keywords: *Usability Goal, Usability Evaluation, Quantitative Approach, Analytic Hierarchy Process (AHP), Novice Designer*

1. INTRODUCTION

Design goals are required to drive the design solution. Prior to producing a usable product, it is important to determine criteria and attributes related to usability. Identifying and specifying a usability goal can lead to the production of a quality, interactive product. In specifying a usability goal, usability attributes or criteria to be used in achieving the goals need to be identified. There is no clear method as to how the usability criteria are to be achieved along the design practice. Conflict of design criteria or attributes could occur in a more complicated design situation. Most experienced designers would depend on their own experience to make decisions. Novice designers would depend on their seniors for direction and advice. In the midst of design complexity our proposed method is targeted to junior designers in order to help them to have a clear usability criterion while designing the prototypes. It would also assist in quantifying the result before a final decision is made. When a conflict in a design situation arises, the prioritization of the usability goal could act as a guide to decide which goal is more important than the others. Furthermore, a decision based on quantified data is strong and convincing, rather than depending on individual intuitive feelings.

We explored the possibility of the multi-criteria method, AHP developed by Saaty [1],[2], to lead the novice designers making decision in designing a usable quality system. We proposed the AHP was applied in the design decision specifically into determine the priority of usability goals of a designed system and subsequently to select the best prototype to fulfill the important goal. The decision framework proposed in this paper consists of two phases, which are namely: prioritizing the goal phase and the user evaluation phase. The overall methodology is depicted in Figure 1. The proposed decision-making method in the design practice aims to help a designer determine a clear and consensus design goals, thereafter choosing the best design prototype before moving on to further development. The approach would guide designers to deliver a good-quality product and avoid having to use their intuition to make a judgement.

2. USABILITY IN SOFTWARE QUALITY

There is no standard definition of usability. Usability is determined by users and it is evaluated subjectively. This was supported by [3] that usability focused on human issues. In software engineering, usability is one of the quality requirements.

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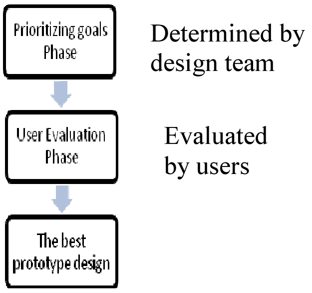

Figure 1: Overall procedure of the model

In other words, it is one of the non functional requirements in which describes how the software will perform a specify task. [4] views usability in two different perspectives. There are narrow approach that relates to well-designed user interface and broad approach that relates to the quality of use in the real world. Similar definition are also found relate to the narrow approach such as in [5], [6], [7], and in broad approach such as in [8].

As researchers have a distinctive definition of usability, so too is criteria in determining usability also different. Results of comparison and evaluation of all usability criteria by [9] showed that learnability, efficiency in use, reliability in use and subjective satisfaction were the most commonly cited. Some usability models comprise usability criteria, or a state of characteristics to achieve a usable user interface. These include namely: operational model of usability [10], model of the attributes of system acceptability [11], framework for usability [12] and user interface variables in the model of usability [13]. Similar to the usage of the usability models, setting and identifying usability goals and criteria could be used to evaluate the existing system and user interface for usability and critique a final product [13]. It could also help in the design process and design evaluation. A usability goal helps to clarify the design process. In usability engineering model [14], a usability goal setting is one of the activities necessary to be performed in the pre-design stage. According to [14], an identified important goal would need to be specified in more detail so as not to appear less important. Sufficient details of the important goals are to allow empirical measurement of the product to achieve these goals. Furthermore, it could drive a design toward a usable interface. In the design process, designers would know what they need to focus on and trade-off, with any further attributes being made if a conflict decision arose.

A determined usability criterion acts as a design goal in design-related work to increase usability. This is shown in the studies of [15],[16] and [17] respectively. An initial survey study in [18] found out that 75% of the respondents (who were industry practitioners in Malaysia) agreed with having usability goals in the project. In another related survey on usability engineering methods in [14] revealed that the activity of having a clear priority in usability parameters to determine the levels on important goals has an impact on improving usability. Thus, it is important to identify and select a usability goal before a particular design work or project starts.

3. DESIGN DECISION

Design is a complicated task. Day-to-day designers are facing challenges such as demanding and stressed users, insufficient information, limited time and resources, increasingly new technology and new materials, which would lead designer makes decision at any time. During the process of interface design, designers make many decisions and judgments in their work. These may include: who to listen to, what to dismiss and how to explore, as well as recognizing and choosing information from all the potential sources. An experienced designer may use their own experiences and skills to make their decisions. While a novice designer may depend on someone senior to him or her to make a decision in this complex situation.

One of the specified decisions designers make is to determine design goals for the project they are involved with. These include: design goals for the system and applications they develop, as well as determining the best design alternatives. A survey by [19], which was conducted on 60 practitioners in the US and the UK, revealed that 85% of the respondents relied on their intuition and experience to interpret their findings in their individual design processes. Furthermore, a comment made from a designer in the design environment, from the extended survey of [18], stated that many people, including those who were not familiar with the design work, were involved in giving opinions on the project. This practice runs the risk of ruining the true design idea.

Usability evaluation involves acquiring feedbacks from users if the design goals are achieved. Usability measurement is comprised of quantitative and qualitative methods. The quantitative method relates to the user's performance of a given task, while the qualitative method relates to the users' subjective satisfaction. Normally, the measures used in the quantitative evaluation methods include: time to complete a certain amount of tasks, number of tasks performed

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in a given time, number and type of errors per task, number of navigations to online help or manuals, the number of users making a particular error, and the number of users completing a task [20]. As for the qualitative method, the examples are user expression and users' comments during the testing. However, the method can be quantified through direct measurements such as questionnaires, interviews or think-aloud sessions during usability testing. As per earlier statement of Wixon and Wilson, usability is quantified, hence not just personal opinion [20]. Accordingly, we suggest looking at another evaluation method of quantitative usability measurement to use in preliminary evaluation.

4. PREVIOUS STUDIES

The Analytic Hierarchy Process (AHP) is a theory of measurement through pair-wise comparisons. It was developed by Saaty [1],[2] and is one of the most widely used multi-criteria analysis approaches. AHP is comprised of three main stages, namely: decomposition, comparative judgement and synthesis of priority. The process begins with evaluators (users of the AHP) decomposing their decision problems into hierarchy. This hierarchy reveals the goal, and set of criteria to be considered, as well as the various alternatives to the decision. The pair-wise comparisons of criteria and alternatives are performed whilst applying comparative judgement. Once the matrix of pair-wise comparisons is constructed, one can calculate the relative priority for each of the alternatives in terms of specific criteria. The comparisons are made using a scale of absolute judgement to reflect the relative preference of one criterion (or one alternative) over another. Preferences are derived from the calculation of composite weight for each alternative using criteria or sub-criteria matrix. The alternative with the highest overall rating is usually chosen.

An analysis study conducted by [21] discovered that AHP is the most reliable research approach for conducting software quality trade-offs. This comprised 13% of 168 publications. Their analysis results showed that AHP mostly applied for or proposed use related to development artifacts. [22] showed that adopting the AHP method in quantitative usability evaluation is reliable. [23] showed that the quantitative method using AHP efficiently evaluates user interface designs as an alternative method to user testing. It was demonstrated further that it is time-consuming and expensive when multiple criteria and several alternatives occur in the design evaluation.

Previous studies showed two purposes of applications of AHP in user interface design, namely: (i) to weight the usability criteria and evaluate the interfaces based on these criteria and (ii) to prioritize usability problems during heuristics evaluation. An evaluation application named Playability Heuristic Evaluation for Educational Computer Game [24], [25] was developed to identify the most critical usability problem. The application was used to adopt an AHP algorithm to derive weights of importance for the identified usability problems of interface, educational elements, content, playability and multimedia. This proposed evaluation method was designed to assist the developers to easily identify usability problems for products or system improvement. Another research study having a similar purpose was done by [26]. This study involved the use of AHP in rating the severity of usability problems during the heuristic evaluation process. The problems were categorized according to design consideration, operation of web site, and user accordance. Another related work was from [23]. They proposed a quantitative model for selecting the best alternative interfaces relative to multiple usability criteria, involving expert and users. We conducted the study to choose the best alternative design using a different approach. We involved interface designers who decide on the design goals and prioritize them before the design work begins. We also included the user's decision in choosing the best design in accordance with the user-based assessment.

5. CASE STUDY

In the case studies included with the students' assignments, four teams were formed with each team consisting of three to four members. The method was evaluated in the user interface design assignment allocated to four groups of students. Even though the chosen application title was based on their interest, they were required to have some transaction processing in their designed system. They could also arrange for some potential users to provide feedback on their design.

For demonstration purposes, a group mini project, titled BOARD, was used in the discussion. There were three students involved in this project design assignment. The BOARD is a mobile application used to share information with people surrounding the user, without restriction. It has a mixture of forum concept and social networking.

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The main functions of the BOARD system are to, namely: view and post gossip, events and launch emergency information, such as car accidents, snatch thieves, missing persons and other relevant cases.

5.1 Methodology

The approach has two main phases, namely: prioritizing goals and the user evaluation phase. The objective of prioritization of the goals phase is to allow all design team members to discuss and set the priority of the four common design goals: learnability, efficiency in use, reliability in use and subjective satisfaction. We used the four common usability goals or attributes adopted from [9] in the prioritization. Table 1 shows the description of the related usability goals or attributes used.

All designers in a team decide the level of importance of usability goals using the pair-wise comparison method. Table 2 shows the description of scale of importance between usability goals. Once the result of the prioritization of design goals has been set, the design team was able to have a clear goal in mind while designing the prototypes. When facing conflict in design issues, the prioritization result could guide them to decide which design goal is more important than the others, thus, leading them to make a decision in design trade-off.

Table : Description of usability goals/ attributes

Usability goals	Description
Efficiency of use	The number of tasks per unit time that the user can perform when using the system or the duration to complete given specific tasks.
Learnability	Users can quickly and easily begin to do productive work with a system that is new to them, with the ease of remembering the way the system operates.
Reliability in use	User error rate when using the system and the time it takes to recover from errors.
Satisfaction	Subjective opinions of the users of the system

The objective of the user evaluation phase is to evaluate the alternative prototypes using quantitative criteria and to select the best alternative. In this phase, user-based assessment such as user testing with usability criteria and measures are involved. After users have gone through usability testing for each design prototype, they are asked to weight their preferences for each design prototype dependent on four usability attributes. The preferences are quantified by using a nine-point scale. Table 3 shows the description of scale of preference between design alternatives.

The stepwise procedure used to evaluate design prototypes using AHP is shown below:

1. Designers employ the pair-wise comparison method on the four main usability goals. Recommended by [2], a nine-point scale as described in Table 2 is in the pair-wise comparison. An approximate weight vector is then calculated to determine the factor weight for each usability goal.
2. Consistency measures on the responses in pair-wise comparison are carried out to ensure the responses to the pair-wise comparison matrix are consistent. If the consistency ratio is greater than 0.10, the decision-makers should consider re-evaluating his or her responses in the pair-wise comparison again.
3. Each user involved in the testing employs the pair-wise comparison method for all alternative designs with respect to usability goals in order to determine the factor evaluations for all alternative designs in all usability goals.
4. An overall ranking should be obtained. This is achieved by multiplying the factor weight for each usability goal (result shown in step 1) with the factor evaluations for alternative designs (result shown in step 3). This will give the total weighted score or overall ranking for all design prototypes. A design prototype receiving the highest total weighted score or highest ranking is then selected as the best alternative.

5.2 Prioritizing Goal Phase

We observed that without discussion among the team members, they did not have a clear and concrete idea of how to develop a usable system. Each respondent had his or her own different design goals that he or she was targeting. Once all teams had determined the application of the system they wanted to design, each team was given a form to determine the weight of importance of the four common usability attributes as their design goals. We used the AHP method to evaluate the consistency of an individual's decision and the goal prioritization. The results of pair-wise comparison matrices with respect to usability goals for three designers are shown in Tables 4, 5 and 6.

Based on the calculation of consistency ratios in each pair-wise of the tables, even though all individual designer decisions are relatively consistent (i.e. less than or equal to 0.10, excepting

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Table 5, which is slightly inconsistent), the prioritization of the goals are different. Thus, a discussion among the members in their own teams was held in order to obtain a decision of the weight of importance of the usability goals or attributes by consensus. The result of their decision is shown in Table 7. The result of the matrix was shown (see Table 7) to all team members to confirm the priority goals of the application they were developing. Based on Table 7, satisfaction was placed as the highest priority, followed by reliability, efficiency and learnability. Based on the priority result, it would help the team to have a clear objective while making design decisions when facing an inverse effect while implementing a usability feature.

5.3 User Evaluation Phase

The team was also required to design the application to a level at least medium fidelity prototype in order to ensure that essential user feedback could be gained during the evaluation. The drawback was that a user has little interaction with the application they have designed, due to the functionality of the prototype. The prototype was not sufficient to allow a user to interact with it alone. During the user evaluation, one of the team members spoke out concerning scenario of test and walkthrough of the demonstration of the first prototype with the user. He was also acting as a chauffeur to guide users to perform a particular task, such as clicking a button to enter the data instead of entering the data into the application using a keyboard. The users in the testing were not tested for their speed of keying in data, but rather their perception of understanding the design element and design flow as well as the concept of the task in the application. Thus, the efficiency test on the data entry was not included. Subsequently, similar steps were followed by the second prototype. Table 8 summarizes characteristics of the users involved in the process.

In testing on efficiency and reliability, the users were given 5 task scenarios which included: new account registration, news posting, event posting and emergency incident posting. While users were performing the test scenario, other team members acted as observers to record the times taken to complete the tasks given, observe users' expressions and listen to users' comments. The result shows that prototype 1 is better than prototype 2 in terms of efficiency and reliability. The result of the comparison of two different prototypes is shown in Table 9.

After the above test, users were asked to test similar steps but different contents on the following day for learnability. This was undertaken in order to test if the design had appropriate features which were able to be remembered after a day of using the new application. The result showed that prototype 1 has better learnability features than prototype 2. The result of the comparison of two different prototypes is shown in Table 10.

The general user satisfaction survey consisted of 16 questions on a seven-point likert scale which focused on, namely: the overall display and organization of content, satisfaction of the layout, privacy and suitability of the tasks performed. Responses from the 3 users showed that prototype 1 has an average of 5.92 points, while prototype 2 has an average rate of 4.37 points. The above result was affirmed again when users were asked to weight their preferences for each of the design prototypes according to four usability attributes based on Table 3. Table 11 shows the normalized matrix of both designs for 3 users and total weighted evaluation for both prototypes.

The result in Table 11 shows the selection of the highest total weighted evaluation as being similar to the traditional results of other evaluation methods on user performance and user satisfaction. The weighted evaluation was obviously showing how far better the chosen prototype compared with the other. Users have enough sense to judge relative preferences using the pair-wise comparison. However, users are tested to judge on two prototypes in this study.

6. DISCUSSION

The suggested quantitative analysis method would assist designers to measure all opinions from the decision-makers in the major design decisions made, which involved choosing design goals and alternative prototypes. The goal prioritization phase initiates the junior designers in the team to discuss getting an agreement on specifying usability goals. This practice enables junior designers to develop a shared understanding of how the application is targeted towards design. Previous studies in usability engineering process have indicated the importance of setting usability criteria and measureable levels for important goals. However, there is no study specifically showing the extent of important goal to be achieved in the design practice.

Comparing the similar purpose of selecting the best alternative design in the previous works, our proposed approach was to use AHP to determine

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the relative importance of four common usability criteria to be set as usability goals. This was in order to deliver quality alternative designs that could fulfill the design objectives and requirements in the early design process. It could thereafter use the relative importance of usability goals in order to decide on an alternative design to fulfill the important usability goals. This approach is appropriate to train novice designers how to bear their collaborative design goals in mind, while at the same time selecting the best alternative design based on users' quantitative assessment results.

In this preliminary study, we analysed the possibilities of user judgement on alternative designs using the pair-wise comparison matrix. Even though only 3 users from a similar group were selected in this study, the result from the pair-wise comparison was confirmed with other common evaluation methods.

Previous reviews in [27] and [28] demonstrated that a total of 5 users in usability testing are sufficient to identify the most prevalent usability problems in a design. In this study, 3 users (who were experienced computer and/ or mobile phone users) were selected for the test. As selecting an alternative design occurs in the early design phase, and further designs and tests are practiced in an iterative design process, it is sufficient to have 3-5 users in this test. Moreover, the test is supported with appropriate qualitative measures in order to understand the design flaw and improvement.

Both results of the common evaluation methods and the proposed quantitative analysis show the same finding in selecting a similar prototype as the best ones. Early involvement of users in the design of the proposed method supports the user-centered design principle. Users participate in the evaluation of prototypes during the preliminary evaluation before more development work is conducted on the selected prototype.

7. CONCLUSION AND FUTURE WORK

This paper presents a quantitative method in the planning of user interface designs. In the first phase, usability attributes are quantified to determine the most important goal for the design. As the goals and priority rankings are set, the design team would have a clear objective in their work. This also acts as a guide in decision-making for the design trade-off. In the second phase, the prototypes of user interface designs are quantified using the weight of the pre-determined usability goals in phase 1 to determine the best prototype to be able to fulfill the design goals. In the result, the proposed quantitative analysis in the preliminary evaluation is similar to common evaluation methods employed in usability testing, in terms of selecting the best prototype.

The proposed approach is particularly suitable when multiple criteria involved in deciding the best interface design and alternative interfaces. In this work, experts were not involved in giving direction or suggestion. The involvement of experts is no doubt an important and common design practice. Experts could be involved to determine the priority of the design goals of the developed system. Further work on a comparative study between the involvement of experts in prioritizing design goals and a consensus decision between designers and involvement of more variety of users were under way by the time this paper was written. The number of users and the number of prototypes involve in the AHP method could probably affect the complexity of the comparison.

Comparing the similar purpose of selecting the best alternative design in the previous works, our proposed approach to use AHP to determine the relative importance of four common usability criteria as usability goals in order to deliver the quality alternative designs that could fulfil the design objective and requirement in the early design process and thereafter using the relative importance of usability goals to decide the alternative design that fulfills the most usability goals.

This approach meets the purpose to prioritize the usability goals and select the best alternative design. With clear goals, it trains the novice designers to bear their collaborative design goals in mind to design towards the achievement of the goals. The result of users' quantitative assessment using AHP could show a strong justification of how far a chosen prototype meets a particular goal compare with the other prototype. However, novice designers are unskillful to determine which feature in the interface could meet the targetted rank of usability goal. This preliminary study will give us direction to our next study on how to guide novice designers meet the ranking of usability goals that has been determined by the expert or among themselves.

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Table 2: Scale of importance between usability goals (adapted from [2])

Preference level of importance	Definition	Explanation
1	Equal important	Two attributes or goals are equally important
3	Moderate important	Experience or judgement slightly important over another.
5	Strong important	Experience or judgment strongly important over another.
7	Very strong important	An attribute or a goal is strongly important over another. Its dominance demonstrated in practice.
9	Extreme important	The evidence of favouring one goal or attribute over another is of highest possible order of affirmation.
2,4,6,8	Intermediate values	Used to represent compromise between the ranks listed above.
reciprocal	Reciprocals for inverse comparison	

Table 3: Scale of preference between design alternatives (adapted from [2])

Preference weights/ level of preference	Definition	Explanation
1	Equal preference	Two designs are equally preferred
3	Moderate preference	Judgment of one design slightly preferred over another.
5	Strong preference	Judgment of one design strongly preferred over another.
7	Very strong preference	One design is strongly preferred over another and its dominance demonstrated in practice.
9	Extreme preference	The evidence of one design is preferred over another and is an affirmation of the highest degree possible.
2,4,6,8	Intermediate values	Used to represent compromise between the preferences listed above.
reciprocal	Reciprocals for inverse comparison	

Table 4: Pair-wise comparison matrix and relative weights with respect to usability goal (Designer A)

Usability goal	Efficiency	Learnability	Reliability	Satisfaction	Factor weights (level of importance)
Efficiency	1	5	3	1/3	0.291 (2)
Learnability	1/2	1	1/3	1/5	0.067 (4)
Reliability	1/3	3	1	1/3	0.151 (3)
Satisfaction	3	5	3	1	0.491 (1)

Consistency Ratio = 0.074

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Table 5: Pair-wise comparison matrix and relative weights with respect to usability goal (Designer B)

Usability goal	Efficiency	Learnability	Reliability	Satisfaction	Factor weights (level of importance)
Efficiency	1	4	3	5	0.506 (1)
Learnability	1/4	1	3	7	0.297 (2)
Reliability	1/3	1/3	1	2	0.129 (3)
Satisfaction	1/5	1/7	1/2	1	0.067 (4)

Consistency Ratio = 0.121

Table 6: Pair-wise comparison matrix and relative weights with respect to usability goal (Designer C)

Usability goal	Efficiency	Learnability	Reliability	Satisfaction	Factor weights (level of importance)
Efficiency	1	5	4	2	0.487 (1)
Learnability	1/5	1	2	1/4	0.117 (3)
Reliability	1/4	1/2	1	1/3	0.092 (4)
Satisfaction	1/2	4	3	1	0.304 (2)

Consistency Ratio = 0.053

Table : Pair-wise comparison judgment matrix and relative weights with respect to the corporative usability goal

Usability goal	Efficiency	Learnability	Reliability	Satisfaction	Factor weights
Efficiency	1	2	1/4	1/6	0.091
Learnability	1/2	1	1/6	1/8	0.054
Reliability	4	6	1	1/3	0.283
Satisfaction	6	8	3	1	0.572

Consistency Ratio = 0.032

Table 8: Profile of users

User	Age	working position	Work nature/ skill
1	22 years	Graphic designer	Designs graphic animations.
2	22 years	Graphic design student	Frequently use the internet for assignment projects, and mobile phone for sharing information and news.
3	25 years	Software developer	Web site freelancer, internet chatting.

Table 9: Average measurement for efficiency and reliability test

Average	Prototype 1	Prototype 2
Number of tasks done (within 5 minutes)	14 tasks out of 15	11 tasks out of 15
Number of errors	2 (click wrong link in a task of replying comment)	3 (forgot to click 'enter data' when needed to enter data)
User expression	Neutral (user 1) Struggleswith posting an event (user 2) Smoothly finished all tasks (user 3)	Struggle a little (user 1) Struggle at clicking links (user 2) Neutral (user 3)

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Table 10: Average measurement for learnability test

Average	*Prototype 1*	*Prototype 2*
Number of tasks done (within 5 minutes)	15 (all tasks were completed)	14 tasks out of 15
Number of errors	<1	2
User expression	Neutral (user 1) Neutral (user 2) Neutral (user 3)	Struggle to find paper clip icon (user 1) A little puzzled when unable to click inbox icon when supposed to click another icon while sending private message (user 2) Neutral (user 3)

Table 11: Analysis result of users

Factor evaluation	Efficiency	Learnability	Reliability	Satisfaction	Total weighted evaluation
User 1					
prototype 1	0.857	0.833	0.875	0.875	0.8711
prototype 2	0.143	0.167	0.125	0.125	0.1289
User 2					
prototype 1	0.833	0.800	0.889	0.857	0.8608
prototype 2	0.167	0.200	0.111	0.143	0.1392
User 3					
prototype 1	0.857	0.750	0.889	0.875	0.8706
prototype 2	0.143	0.250	0.111	0.125	0.1294
Average total weighted evaluation					
prototype 1	2.6025 / 3 = 0.8675 (86.75%)				
prototype 2	0.3975/3= 0.1325 (13.25%)				