A Quantitative Approach in the Usability Evaluation of A Courseware
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Abstract
Usability evaluation is a critical part in an application development process and currently there are many techniques which have been developed by HCI researchers in the usability evaluation of a system. One of the commonly used techniques in evaluating usability is Heuristic Evaluation (HE). In this research, the courseware had been evaluated based on HECW which contains 4 main heuristics; Interface, Educational Elements, Content and Additional Elements. The data collected were analyzed based on a quantitative approach known as Usability of HECW (UsabHECW). UsabHeCW is a function to calculate the total percentage of the courseware usability. Based on the usability analysis, the critical usability for the courseware in each category had been determined. The analysis had been able to identify which sections of the courseware are critically to be corrected and improved. The usability analysis which is based on UsabHeCW has proven to be a reliable technique in identifying usability problems for the courseware. The presentation of result in the form of percentage is a distinctive result from this analysis, while the process of analyzing usability problem could be done faster.

Keywords: Quantitative Approach, Usability Evaluation of Coursewares, Heuristic Evaluation

1. Introduction
Usability evaluation is a critical part in an application development process. Currently, usability is an increasingly important factor that influences the success or failure of a product [1]. There are many techniques which have been developed by HCI researchers in the usability evaluation of a system. Usability evaluation has been accepted as a reliable tool to test whether the system has been designed and developed according to the user’s requirements [2]. Among the various definitions of usability are the capability of the system to be used easily and effectively [3], quality in use [4] and the effectiveness, efficiency, and satisfaction in its goal achievement [5]. Nielson [2] defines usability evaluation based on five constructs which are learnability, efficiency, memorability, error and satisfaction. One of the commonly used techniques in evaluating usability is Heuristic Evaluation (HE). HE is an evaluation method commonly used to find usability problems at different development stages of a product. HE is being used by expert evaluators to examine the interface of any applications before the application can be released [6]. HE is done during the design process in order to find flaws earlier rather than later. This is able to reduce usability errors, which may be more costly to be fixed once the application or system is completed.

Quantitative analysis for HE previously had been used by González in the UsabAIPO project [7]. In his project, González had defined a function, named USABAPO-H, whose purpose is processing quantitative results of Spanish Universities websites heuristic evaluation [7, 8]. In this research, functions which are Usability of HECW (UsabHeCW) and F(x) have been used to help in analyzing the data. The usability evaluation for the courseware had been conducted based on Heuristic Evaluation of Courseware (HECW). HECW is a set of heuristics used in the evaluation process specific for courseware [9]. This research had analyzed a Mandarin language courseware and there were 10 Mandarin language instructors who had been appointed as the experts. The data which had been collected from the evaluation were analyzed to obtain results based on Usability of HECW...
UsabHeCW is a statistical function proposed to calculate the total percentage of the courseware usability. UsabHeCW is a new approach in analyzing courseware usability problems and is expected to produce more reliable and presentable results. The presentation of result in the form of percentage is one of the distinctive results from this process. This will help courseware developers to shorten the process of analyzing usability problems.

2. Literature Review

2.1. Usability Evaluation of Courseware

Over the years, there is an increasing interest in the usability of applications based on emerging information technology [10]. Courseware usability is the extent to which a computer system enables learners, in an organizational context, to achieve specific learning goals effectively, efficiently and satisfactorily, due to the capability of the software to be attractive to the user, understood, learned and used under learning conditions [11]. Usability is one of the main and core concepts that have emerged from the human–computer interaction (HCI) field. The widely used definition of usability is based on definition by International Organization for Standardization (ISO) “the extent to which the product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” [5]. [12] had evaluated the courseware based on ease of use, screen design and navigation, information presentation and media integration. While [13] had conducted courseware evaluation based on five usability construct: effectiveness, learnability, ease of use, flexibility and attitude.

2.2. Heuristic Evaluation (HE)

Heuristic Evaluation (HE) is an inspection evaluation technique that is normally being used by an expert to find usability problem in any system [14,15,16]. HE is commonly used for formative evaluation where the product or system is still in the development process. HE is a light-weight process that can be cheap, fast, and easy to apply in an evaluation process. It can be used both in design and evaluation phases of development and can even be applied to paper-based designs before the first working prototype is created [16]. HE involves a small number of evaluators who have been assigned to inspect a system according to heuristics or guidelines that are relevant and focused on the interface of the system. In HE, 3-5 expert evaluators are necessary [1]. HE using non-experts is appropriate at times depending on the situation. Less-experienced people can perform the HE, but the results might not be the best [1]. HCI studies showed that using five evaluators may be enough to find most usability problems, adding more would reduce the benefit to the cost ratio, and suggested that three may be adequate [16].

2.3. Heuristic Evaluation for Courseware (HECW)

Heuristic Evaluation of Courseware (HECW) is a set of heuristics used in the evaluation process specific for courseware [17]. There are four Heuristics in HECW which are Interface, Educational Element, Content and Additional Elements. The 4 Heuristics consist of overall 27 sub heuristics for the expert evaluators. Heuristic for Interface is consisting of 10 sub heuristics, Educational Elements is consisting of 6 sub heuristics, Content is consisting of 6 sub heuristics and Additional Element is consisting of 5 sub heuristics. The data collected from HECW is to be evaluated with a potential quantitative approach known as UsabHeCW. Table 1 shows the HECW.
2.4. Usability of HECW (UsabHECW)

The data collected from HECW is analyzed by using a quantitative approach known as UsabHeCW which caters on the Interface, Content, Educational, and Additional Elements issues. UsabHeCW is a function which calculates the total percentage of the courseware usability. UsabHeCW is a new approach in analyzing courseware usability problems to produce more presentable results. UsabHeCW has been derived based on the USABAIP-O-H function, which was developed by González to estimate the degree or level of usability of the website. The approach is one of the promising attempts to quantitatively analyze the results of a usability evaluation based on the HE method [18]. In UsabHeCW calculation, some modifications had been done in order to simplify the analysis process developed previously by González. Research in [18] was based on UsabaIPO project that initiated new experiment to obtain quantitative result after a heuristic evaluation process. Numbers of heuristics and subheuristics are important considerations in developing the functions and overall calculation. Usability level can be considered good when its value higher than 80% and 100%. It conveys the meaning that all subheuristics are satisfied or fulfilled [18].
2.5. Multimedia Courseware

The courseware is a combination of still and moving pictures (video), audio, text and graphics with many interesting elements such as attractive, dynamic, interactive and effective [19]. The interactive nature of multimedia courseware is considered to be its most important learning feature and enables students to achieve topic goals and to receive meaningful intrinsic feedback [20]. The use of multimedia in teaching, which aims to enable students to grasp the knowledge more firmly, requires a well-designed multimedia courseware which blends text, images, simulations, video, audio and other multimedia material into a single, coherent environment [21]. [22] found out that by using multimedia courseware, there is more learner control, students are motivated and are engaged in learning. This is because they can construct their own individual paths through the courseware, control the pace at which they work and decide for themselves how much coaching or “scaffolding” they need [22]. Compared to the conventional way of learning, the courseware encourages the process of learning to be more goals oriented, more participatory, and flexible in time and space tailored to individual learning styles. This could promote learning to be more fun and friendly, without fear of inadequacies or failure while enabling learning through exploration, discovery, and experience [23].

3. Methodology

3.1. Research Method

The courseware had been evaluated based on HECW which contains 4 main heuristics; Interface, Educational Elements, Content and Additional Elements. Heuristic for Interface is consisting of 10 sub heuristics, Educational Elements heuristic is consisting of 6 sub heuristics, Content heuristics is consisting of 6 sub heuristics and Additional Element heuristic is consisting of 5 sub heuristics. All of the heuristics are weighted based on sub heuristics. This process is adapted from [18]. Table 2 shows the heuristics, the number of subheuristics for each heuristic and its weighting used to calculate the total percentage of the courseware usability.

<table>
<thead>
<tr>
<th>Heuristic</th>
<th>Total Subheuristics</th>
<th>Weight of heuristic</th>
<th>Weight of heuristic (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface (I)</td>
<td>10</td>
<td>0.3704</td>
<td>37.04</td>
</tr>
<tr>
<td>Educational Elements (E)</td>
<td>6</td>
<td>0.2222</td>
<td>22.22</td>
</tr>
<tr>
<td>Content (C)</td>
<td>6</td>
<td>0.2222</td>
<td>22.22</td>
</tr>
<tr>
<td>Additional Element (S)</td>
<td>5</td>
<td>0.1852</td>
<td>18.52</td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>1</td>
<td>100</td>
</tr>
</tbody>
</table>

In order to rate the severity of usability problems found in the courseware, heuristic evaluation rating scale as shown in Table 3 is used [24].

<table>
<thead>
<tr>
<th>Rating Scale</th>
<th>Severity of Usability Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>I don't agree that this is a usability problem at all</td>
</tr>
<tr>
<td>1</td>
<td>Cosmetic problem only: need not be fixed unless extra time is available on project</td>
</tr>
<tr>
<td>2</td>
<td>Minor usability problem: fixing this should be given low priority</td>
</tr>
<tr>
<td>3</td>
<td>Major usability problem: important to fix, so should be given high priority</td>
</tr>
<tr>
<td>4</td>
<td>Usability catastrophe: imperative to fix this before product can be released</td>
</tr>
</tbody>
</table>
The formula, called UsabHECW(x), is as follows:

\[
USABHECW(x) = \left( \frac{I}{0.3704} + \frac{E}{0.2222} + \frac{C}{0.2222} + \frac{S}{0.1852} \right) / 4 \tag{1}
\]

where I represents the Interface, E is for Educational, C for Content, and S for Additional Element. Based on the UsabAIPO, USABHECW(x) gives an estimation of the degree or level of usability. UsabHeCW is referred to as weighted mean and it is the value of overall usability of the courseware. Each variable I, E, C and S obtain their values from the following formula:

\[
F(x) = \left( \frac{\sum H}{\sum H_t} \right) \times P \tag{2}
\]

\(\sum H\) is the summation of the severity scores for each heuristic category as follows:

\[
\sum H = \sum (\text{severity rating} \times \text{number of severity found})
\]

\(P\) is the percentage for the current category, and \(\sum H_t\) represents the summation of the heuristic categories in the worst case (in the event that all severity ratings were 4). For example, if there are 3 severities found for severity rating 4, therefore

\[
\sum H_t = 4 \times 3
\]

Table 3, function (1) and function (2) are derived from functions developed by González which is one of the promising attempts to quantitatively analyze the results of a usability evaluation based on the HE method [18]. In this research, function (2) has been modified in order to simplify the calculation.

### 3.2. Evaluation Process

There are five steps involved during the evaluation process. First, the experts were identified and invited by researcher to perform the HECW. The experts who had agreed to join the evaluation process were scheduled to perform the evaluation. Experts then performed the evaluation based on HECW with the explanation on how to conduct the process. Experts then had to identify usability problems and rate the problems based on severity scale. Once the evaluation had finished, the researcher collected the data and then performed the analysis. Figure 1 shows the flow of the evaluation process.

![Figure 1. Evaluation Process Flow.](image-url)
There were 10 Mandarin instructors who were identified as experts involved in the evaluation. Among the experts, 5 of them had to evaluate content heuristic while another 5 experts had to evaluate educational heuristic. All of them had to evaluate the interface and additional elements heuristics. The experts had to navigate through all sections of the courseware, tested the sounds and most of all to understand how the courseware was structured. They had to find if there were any flaws of the courseware according to the Heuristic Evaluations for Courseware (HECW) provided. Experts’ involvement in evaluation process shows a significant impact in identifying usability problems based on their knowledge and experience. Table 4 shows the profile of the experts and Table 5 shows the numbers of usability problems found by all the experts.

<table>
<thead>
<tr>
<th>No</th>
<th>Expert Evaluators</th>
<th>Highest Qualification</th>
<th>Professional Role</th>
<th>Duties/course taught</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interface/ Educational/Additional Element</td>
<td>BSc</td>
<td>Science and Chinese teacher in primary school</td>
<td>Experience in teaching Science and Chinese for the past 3 years</td>
</tr>
<tr>
<td>2</td>
<td>Interface/ Content/ Additional Element</td>
<td>BSc</td>
<td>Lecturer in Academy of Language Studies</td>
<td>Experience in teaching Chinese for more than 25 years</td>
</tr>
<tr>
<td>3</td>
<td>Interface/ Content/ Additional Element</td>
<td>MSc</td>
<td>Senior lecturer in Business Studies</td>
<td>Experience in teaching Chinese on part time basis for more than 4 years</td>
</tr>
<tr>
<td>4</td>
<td>Interface/ Content/ Additional Element</td>
<td>Msc</td>
<td>Senior lecturer in Political Studies</td>
<td>Experience in teaching Chinese on part time basics for more than 4 years</td>
</tr>
<tr>
<td>5</td>
<td>Multimedia</td>
<td>MSc</td>
<td>Senior officer in IT and multimedia</td>
<td>Working in private sector as multimedia producer for more than 3 years</td>
</tr>
<tr>
<td>6</td>
<td>Interface/ Content/ Additional Element</td>
<td>Teaching diploma in Chinese</td>
<td>Retired Chinese teacher</td>
<td>Experience in teaching Chinese for more than 25 years</td>
</tr>
<tr>
<td>7</td>
<td>Interface/ Content/ Additional Element</td>
<td>Teaching diploma in Chinese</td>
<td>Primary school headmistress</td>
<td>Experience in teaching Chinese for more than 15 years</td>
</tr>
<tr>
<td>8</td>
<td>Interface/ Content/ Additional Element</td>
<td>Teaching diploma in Chinese</td>
<td>Primary school teacher</td>
<td>Experience in teaching Chinese for more than 5 years</td>
</tr>
<tr>
<td>9</td>
<td>Interface/ Content/ Additional Element</td>
<td>Teaching diploma in Chinese</td>
<td>Primary school deputy headmistress</td>
<td>Experience in teaching Chinese for more than 15 years</td>
</tr>
<tr>
<td>10</td>
<td>Interface/ Educational/Additional Element</td>
<td>BSc</td>
<td>Science and Chinese teacher in primary school</td>
<td>Experience in teaching Science and Chinese for the past 5 years</td>
</tr>
</tbody>
</table>
4. Results And Discussion

4.1. Extracting Result Analysis

The first step in this usability analysis is to find the values for $\sum H$ and $\sum Ht$. In order to find the values, severity rating 4 should be given high priority as they are considered as ‘usability catastrophe’ [24]. Based on Table 5, calculation of $\sum H$ and $\sum Ht$ for I is as follows:

$$\sum H = (4*5) + (3*13) + (2*2) + (1*0)$$
$$= 20 + 39 + 4$$
$$= 63$$

$$\sum Ht = (4*5)$$
$$= 20$$

The rest of the calculation for Interface (I) is as follows:

$$F(I) = \frac{\sum Ht}{\sum H} \times \text{Percentage Weight of Interface Heuristic}$$
$$= \frac{20}{63} \times 37.04$$
$$= 11.76$$

$$F(I)\% = \frac{11.76}{37.04} \times 100$$
$$= 31.75\%$$

The meaning of $F(I)\%$ is that from overall 37.04, the critical evaluation for Interface is 11.76 or 31.75%. The calculation for each E, C, and S are shown in Table 6.

<table>
<thead>
<tr>
<th>Table 5. Usability Problems Found and Severity Score By Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Interface (I)</td>
</tr>
<tr>
<td>Educational Element (E)</td>
</tr>
<tr>
<td>Content (C)</td>
</tr>
<tr>
<td>Additional Element (S)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 6. Calculation for Each Heuristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Interface (I)</td>
</tr>
<tr>
<td>Educational Element (E)</td>
</tr>
<tr>
<td>Content (C)</td>
</tr>
<tr>
<td>Additional Element (S)</td>
</tr>
<tr>
<td>Mean (indicator)</td>
</tr>
</tbody>
</table>
4.2. Evaluation Result

UsabHeCW was used to calculate the overall critical usability problems found in the Mandarin courseware based on the 4 heuristics:

\[
USABHECW(x) = \frac{(I/0.3704) + (E/0.2222) + (C/0.2222) + (S/0.1852)}{4}
\]

\[
USABHECW(x) = \frac{(11.76/0.3704) + (3.56/0.2222) + (3.7/0.2222) + (8.23/0.1852)}{4}
\]

\[
USABHECW(x) = \frac{(31.75) + (16.02) + (16.65) + (44.44)}{4}
\]

\[
USABHECW(x) = 27.22
\]

Based on the analysis, the percentage values for each of the critical usability problems found for I, E, C and S were 31.75%, 16.02%, 16.65% and 44.44% respectively. The mean value for USABHECW(x) was 27.22% which represented the overall critical usability problems for the courseware.

Studied by [17] has mentioned that a good usability level is when the value is higher than 80%. Based on the mean value of the overall critical usability problems, the usability level of the Mandarin courseware is able to be determined [25]. It shows that the usability level of the courseware is 72.78%. This means that the courseware is still needed to be improved and corrected in certain categories.

The overall critical usability problems found is much easier to be viewed in visual format as shown in Figure 2. Based on Figure 2, the most critical usability problem comes from Additional Element which contributes 44.44% and is followed by Interface which contributes 31.75%. Another two heuristics which are Educational Element and Content contributes 16.02% and 16.65% critical usability values respectively. These two values which are under 20% are considered as non-critical [25]. From this analysis, it could be concluded that the Interface and the Additional Element of the courseware are the sections that are needed to be focused and improved as their critical usability values are greater than 20% [25].

![Critical Usability Problem for Mandarin Courseware](image)

Figure 2. Percentage of Critical Usability Problem for Mandarin Courseware
5. Conclusion

The usability analysis which is based on quantitative approach has enabled the researcher to identify which sections of the courseware are critically to be corrected and improved. Based on this usability analysis, the critical usability for the Mandarin courseware in each category which are Interface, Educational Elements, Content and Additional Elements have been determined. It could be concluded that the Interface and the Additional Element are the sections that are needed to be improved as their critical usability values are greater than 20%. Based on the result, researcher should focus more on the improvements for both sections. The overall usability problem of the courseware is also been able to be determined from the analysis. The overall usability level of the courseware has indicated that the courseware is still needed to be improved and corrected in certain categories. The usability analysis which is based on UsabHeCW has proven to be a reliable technique in identifying usability problems for the courseware. The presentation of result in the form of percentage is a distinctive result from this analysis, while the process of analyzing usability problem could be done faster.

6. Acknowledgment

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7. References


