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Research paper

Goal-Directed Approach and Design Principle Approach: a Comparative Study

Hoo Meei Hao[1]*, Azizah Jaafar[2], Beh Hooi Ching[3]

[1,3]*Universiti Tunku Abdul Rahman*
[2]*Universiti Kebangsaan Malaysia*
**Corresponding author E-mail: hoomh@utar.edu.my*

Abstract

Uncertainty arises from intuitive design, prioritize usability goal, trade-off among usability attributes, choose usability patterns, conflict opinion during evaluation are putting more difficulties for novice designers in design tasks. As previous studies focused on the effectiveness of novice designers through the use of design patterns, we extended the use of usability pattern to look into the delivery of prototype design. Furthermore, in the aspect of usability analysis, Analytical Hierarchical Process (AHP) technique was applied in the prioritization of usability criteria and usability problems. In this study, AHP is used to prioritize the usability goals and integrated with usability testing and cognitive walkthrough to affirm the result for better judgement. We developed the approach to guide novice designers for the achievement of the targeted usability goal and supported with a tool to capture the collective decisions in providing convinced result during comparative evaluation. We built the approach and compared it using an experimental study with the undergraduate students. Our results suggested that prototype designed by novice designers followed usability pattern approach would has more usability patterns applied into and was preferred by experts than using design principle approach.

Keywords: *Analysis hierarchical process; Design decision; Design pattern; Usability goal achievement*.

1. Introduction

Result from a survey on usability engineers had showed that usability goal setting has impact on improving usability, however these was less practised in the project development, in which only 38% of total number of projects have goal setting [1]. Goal setting is indeed important as it gives direction in establishing an evaluation method. Even though the guideline of goal setting was relative moderate importance, it is still one of the important methods in usability engineering life-cycle. Some researchers in design field have conducted studies related to the goal setting such as Jokela et al [2], Joshi [3] and Joshi & Sarda [4]. A few of studies on goal setting from various background were conducted such as 'wow' design goal [5], quality goal [6], usability goal [3], [7]–[9] and user goal in web navigation [10]. Furthermore, Nielsen [1], Ferre et al [11], and Seffah and Metzker [12] has stressed usability goal as usability benchmark that was determined in early design stage. Mostow and Rey [13] also emphasized that design decisions, rationale for design decisions, and control of design process were started from the given goal. Thus, the study of goal setting can be explored, and method to fulfil the determined goal along the design process is not well-established.

There are various design guides to be used during system design and evaluation such as rules, principles, guidelines and pattern. All these are to improve usability of a system or application design and provide guidance in using design knowledge. Design principles are abstract design rules, explained in prescriptive style and formed from the mixture of theory and knowledge in psychology, mathematics, and sociology [14]. Design principles are also called heuristic in the concept of design practice and provide suggestions on the necessity and issue should be avoided during user interface design. In usability aspect, the related principles are more specific than design principles. Usability principles are mostly used as heuristic evaluation during the evaluation of the acceptance of interface design. Examples included 8 golden rules [15], 10 usability heuristics [16], Donald Norman's design principles that are explained in [17], Stone's principles [18], and Johnson's principles [19]. Design guidelines comprise principles and style guides. Alan et.al [14] distinguished them on the level of details that use in different design stage. Abstract guidelines or design principles are used during early design stage while detailed guidelines or style guide are used during design.

Meanwhile, the first experiment on pattern language conducted by Beck and Cunningham [20] showed a success used of pattern concept for inexperienced developer in interface design. Different from general guidelines, design patterns are constructive [21] that could expand to a new pattern for a new solution. Previous works in Koukouletsps et. al [22] and Welie, Van Der Veer and Eliens [23] explored the use of guidelines and patterns as an aid to teach design. The result from Koukouletsps et. al [22] showed the use of design patterns has greater impact on the novice designer's performance than guidelines. Nevertheless, there is still other aspect can be discovered besides the effectiveness of design pattern among novice designer, such as the quality of the prototype using design pattern, metrics in evaluating pattern, selection of appropriate pattern, and effectiveness in the user-centered design process. These had asserted by Wesson et. al [24].

Design practice among novices and experienced are different from the aspect of problem solving. Previous study had focused design practice, design approach, and behavior in design process for the comparisons [25]. Result from Ahmed, Wallace, and Blessing [26] and Anwar, Abidin and Hassan [27] showed novice designers faced problems in making decision and learned through trial and error technique. Novices designers are in the midst of sharpen their knowledge and still in a learning stage of becoming experienced designer. They depend on the principles and guidelines without any method to support them to design in achieving usability. While experienced designers rely on the available design guidelines, past design experiences, templates and problem-solution sets from previous experiences. This is agreed by Rogers [28] that claimed practitioners were depend on their intuition and experiences gained. Thus, novices would find difficulties in designing intuitively if experience and knowledge are not sufficient gained. As emphasizing on the priority of usability goal and trade-off among usability attributes are the common activities in usability engineering, trade-off usability attributes should be determined carefully as it always conflict with others attributes [11], [29]. However, it is beyond the knowledge of novice designers to make decision on prioritization and trade-off. In addition, reviews on the designed prototype are commonly depends on experts through expert-based method and users through testing method. Evaluation involves more than one evaluators often occur conflict of opinions. Uncertainty arise from intuitive design, prioritization of usability goal, trade-off among usability attributes, choose usability patterns, conflict opinion during evaluation are giving complications in their design tasks.

Hitherto, two main purposes of the application of Analytical Hierarchical Process (AHP) in user interface design are found. First, usability criteria and measures have been weighted by the AHP method and design interfaces have been evaluated based on weighted criteria. Studies in this direction include Ji et al [7], Shrestha, Abdinnaur-Helm and Chapparo [9], Mitta [30], Park and Lim [31]. Second, usability problems were prioritized during heuristic evaluation such as in Omar and Jaafar [32], Kilic and Gungor [33]. Different from the previous studies, in this study, AHP is used to prioritize the usability goals and integrated with usability testing and cognitive walkthrough to affirm the result for better judgement. This work was the extension from the prior studies in [34].

The objective of this paper is to evaluate and compare the goal-directed approach with design principle approach in delivering user interface prototype fulfilling the pre-determined usability goals. We compare these two approaches on the quality of the prototypes designed based on the evaluation by the industry practitioners. The goal-directed approach comprises the application of AHP technique in prioritizing the common usability goals and prototypes, and task-mapping template that drives the novice designers to achieve the targeted usability goals. The tool which was based on the AHP technique, captured users' and experts' decision in selecting the best prototype, thereafter helping the novice designers to know the best choice of prototype based on the targeted usability goals.

The following section details out the difference of goal approaches, usability patterns and methodology of AHP. The proposed goal-directed approach and tool that assists in decision-making direction explained in the next section. Subsequently, section four focuses on the experiment of the proposed method is shown. In the next section, result and discussion are given. Finally, we provide our conclusion and future work.

2. Literature Review

This section provides a brief introduction to the theory behind the creation of the concept of goal-directed. It comprises the main discussion of goal-oriented design approach, usability pattern, and AHP and its technique.

2.1. Goal-oriented design

Design is the process to produce an artifact that will be used by the user. In research point of view, Dorst [35] divided the design process into two, namely, the problem solving process in a rational or goal-oriented, and the learning process that is characterized as reflective practice. Similarly, architectural designers usually practice the strategy focus on solutions, also called synthesis while scientist focused on the problem to find the optimal solution in analysis. Moreover, Gasson [36] distinguished the two design approaches which are the goal-directed approach and goal-driven approach. The goal-directed approach is defined as product and development driven. He described this approach was appropriate for well-defined problem. It was different from goal-driven approach which deals with unstructured problems in which there was no obvious way to get a solution. The controversy in both design philosophy can be seen from the method of problem solving. Research in architecture environment strengthen the use of systematic method and guided by rules in order to avoid designers rely on their intuitive problem solving [37]. Moreover, experimental studies carried out by Sun, Yao and Carretero [25] for designers in different experiences indicated systematic design methods can improve the efficiency of cognitive designers who lack of experience and knowledge. The cognitive skill was used to evaluate the performance of the designers in the experiment and it represented mental effort and the creativity of designing. Recently, some studies adopting goal-directed approach in requirement and design such as in designing learning health system [38], and gain insights into user requirements [39]. These studies showed systematic of design can guide designers to do their work rationally. Put it altogether, we defined goal-directed design approach as a systematic and rational way of problem solving in product or application design under the condition that the problems or requirements were clearly defined. We used this concept to direct our effort in decision-making towards achieving usability as a goal in design.

2.2. Pattern in Design

Usability design pattern are incorporated into the design process to provide solution in achieving usability as asserted in Borchers [21], Granlund, Lafreniere and Carr [40], Welie [41]. The use of pattern appears as possible solutions to some problems from which guidelines failed, was discussed in Welie, Van Deer Veer and Eliens [23]. Furthermore, findings from the previous empirical studies of Koukouletsos et al [22], Thongmool and Phankokkruad [42] and Borchers [43] were regarding the application of the design patterns and guidelines in design teaching to the novice designers, method to address behaviour problems [44] and delivering good usability [45]. Granlund, Lafreniere, and Carr [40], Kotze et. al [46], Welie and Tratteberg [41] and Tidwell [47] explained the differences of design patterns and categorized them into two types. Firstly the design pattern in software engineering explained the structure and implementation of the software. It focuses on the relationship between component interfaces. Secondly, interaction design patterns in the domain of human-computer interaction. It captures the nature and behavior of interaction system understood by users. There are many patterns related to human-computer interaction which have different focus and name, such as, interaction pattern [48], user interface pattern [41], usability pattern for graphical user interface application [49], and usability pattern in web [50]. Folmer and Bosch [51] created a framework of relation between usability attributes, usability properties and usability patterns that served as a technique to assess software architectures in supporting usability. This concept of relation between usability attributes or goals and usability patterns could introduce another concept of selecting usability patterns in achieving optimal usability goal. This is shown in the section III.

2.3. Analytical Hierarchical Process (AHP)

AHP is a process of rational decision theory in making decision involving multi criteria that help decision makers determine the position of choice when all the criteria in the decision-making process are to be considered simultaneously. According to Satty [52],[53], AHP methodology solves various multi-criteria decision-making problems in 4 steps: (i) Define problem and solution objective; (ii) Create pairwise comparison matric for all criteria, sub-criteria, and alternatives. The decision maker compares each of the paired elements in the matrices using a questionnaire of nine-point scale as recommended by Satty and Islam [54]. The weights of each criteria, sub-criteria, and alternatives are determined; (iii) Calculate the consistency ratio to screen out inconsistent responses. In general, Satty [55] proposed the cut-off point for acceptable consistency ratio is 0.10; (iv) Weighted criteria is scored by decision maker and then total weighted score is calculated if it involves a set of alternatives.

3. Goal-Directed Approach

The goal-directed approach consists of three main activities that support the planning, designing and early evaluation stages. These include prioritizing usability goal, designing user interface and evaluating and selecting prototype. In the planning stage, the priority rank of four common usability goals (efficiency of use, reliability in use, learnability and satisfaction) for a designed prototype is acquired from the experts. The result was served as a direction in the designed prototypes for the designers to determine the patterns applied to the prototype's functionality. Ultimately, the designed prototypes are evaluated and compared to determine the best prototype fulfilling the pre-determined usability goals. The method of prioritization and prototype selection were adapted from Satty [52],[55] multi criteria analysis approach called AHP. Figure 1 shows an overall flow of the approach. Further discussion on the methodology of prioritization and prototype selection using AHP method and usability goal achievement can be found in [34].

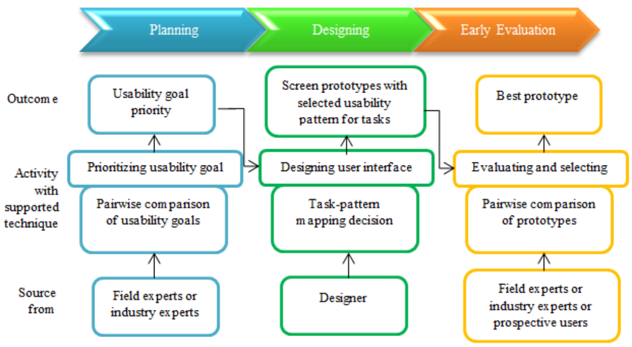

Fig. 1: Overall flow of goal-directed approach

4. Experimental Design

An experimental study with the undergraduate students was conducted to understand the application of the approach. The experiment was conducted for 14 weeks. There were 6 groups consisting of 3 students in each. All students were in Year 2 software engineering program involved in the user interface design of stationery managing system (STAT) for a faculty in a university. They were given the process flow for stationery stock managing, and stationery requisition form to understand the data requirements. Thereafter, each group was designing an interactive prototype using a prototype tool after understanding the requirements and problem faced by the users. In the evaluation stage, they were required to arrange their peers as surrogate users to provide feedbacks on their design and selection of a comparative prototype with another group of using different design approach. The decisions of prototype selection were assisted by the tool adopting AHP method. The methodology of the development tool can be found in [56]. Human performance measurements on the duration to complete the given tasks, number of user's error, and satisfaction survey as well as comments on each evaluated prototype were collected during usability testing with users.

4.1. Experimental Setup

In managing the groups, survey questions were given to obtain their experiences, interest and academic performance. The grouping in the experiment was determined based on the responds in the survey to ensure each group has mixture of experiment and skill in managing project, design and programming, with different level of academic performance such as cumulative grade point average less than 2.0, between 2.0 to 2.99, and more than 3.0. Of 6 groups, 3 of them were following usability pattern approach (named as SG group) and another 3 groups were following the 8 golden rules [15] of user interface design principle (named as IG group) in achieving the prioritized usability goal. The 8 golden rules by Schneiderman and Plaisant [15] comprises of: (i) strive for consistency in using familiar icons, colours, menu, call-to-actions, and user flows, (ii) support of frequent users to use short-cuts, (iii) offer informative feedback, (iv) design dialogue to yield closure to inform user what action has led them to, (v) offer simple error handling such as step-by-step instructions to solve problem as fast as possible, (vi) permit easy reversal of actions to encourage exploration of unfamiliar options, (vii) support internal locus of control, and (viii) reduce short-term memory load.
All groups were revealed of the priority ranking of the usability goals given by experts, and were focused to design the identified 6 functions. There were namely: create stationery items, create new staff user, obtaining information or report of low stock items, making requisition, send notification for stationery collection, and verify the collected items. IG groups were applying the 8 golden rules while SG groups were applying usability patterns into the identified functions.
All SG groups were provided with list of pattern design guidelines, usage descriptions and supported by examples, and a template to fill up their selected-pattern decision. The novice designers decided the appropriate patterns for all identified designed tasks and matched the targeted usability goal set by the experts. The decision to trade-off the pattern usage was based on the auto-generated percentage of each targeted usability goal that had grouped patterns related to the usability goals. The experts then reviewed the decisions of selected-pattern and recommended some relevant patterns for the task designed. Members of the IG groups were explained the meaning of all 8 golden rules supported with examples.

5. Results and Discussion

5.1. Analysis of the Usability Goal Prioritization

Five industry experts involved in system design and development were selected to prioritize the given four common usability goals (efficiency of use, reliability in use, learnability and satisfaction) for the design of STAT. Of five industry experts, only three of them were selected to aggregate their decision of usability goal ranking. The selected decision was based on the value of consistency ratio (CR) less than 0.10 for pairwise comparison of four usability goals. We applied the general acceptance of CR is less than 0.10 for all decision makers. If CR is greater than 0.10, the decision maker is relatively inconsistent and should consider to reevaluate his or her responses. Table 1 shows the three expert's profile.

Table 1: Experts' profile

Job Position	Year of experience in profession	Types of application software develop and/or evaluate
Consultant	7-9 years	Enterprise software
Functional Analyst	4-6 years	Enterprise software
Team lead	7-9 years	Database software, software system

Figure 2 shows the aggregated judgement of three experts' decision that was generated by a developed tool adopting AHP. The approximated aggregation of the three experts' decisions of weight of each goal was translate into the priority and thereafter used to determine the best prototype during the comparative evaluation. In designing user interface for STAT, reliability in use is the highest priority 58% (0.578), followed by efficiency of use 23% (0.232), and both learnability and satisfaction 9.5% (0.095). This was served as a goal for novice designers to target to.

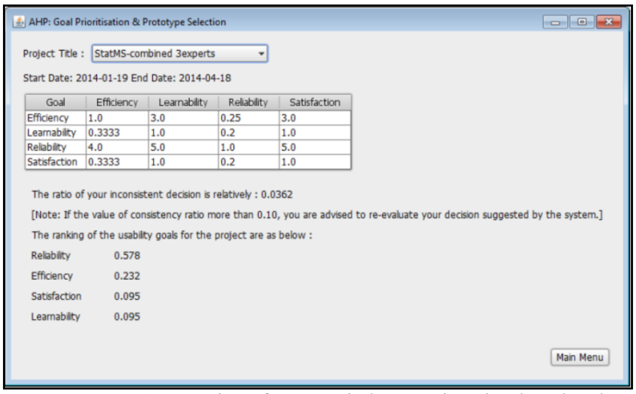

Fig. 2: Aggregation of experts' judgement in a developed tool

5.2. Analysis of Usability Goal-Fulfilment

Figure 3 and Figure 4 summarized the usability goal achievement (number of patterns and the percentage applied) in their prototype designed for usability pattern approach and design principle approach respectively. The usability patterns used in this study were adopted from 19 user-perspective patterns of interaction patterns [57], 21 architectural usability patterns [58], and 10 functional usability pattern [59]. All these patterns were categorized into four common usability goals namely: efficiency of use, reliability in use, satisfaction, and learnability. The number of patterns was computed based on the compilation of the grouping of usability patterns according to the four common usability goals. Some patterns have positive or negative inter-relation with other usability goals, for instance, 'undo' is a pattern supports efficiency of use, reliability in use and satisfaction. 'Context sensitive help' is a pattern supports reliability in use but has negative effect on efficiency of use. The total patterns that related to other patterns refer to the total number of patterns in all 4 categories of usability goals regardless of redundancy of a pattern in other categories. The total net pattern is referred to the net number of patterns applied in the whole designed functions.

We observed that all SG groups could achieve reliability in use as the utmost priority in the design plan after feedbacks and recommendations obtained from instructor. In implementing the patterns in design, even though certain target of usability goal were quite far from the percentage weighting given by the experts, the ranking of usability goal over the number of functions implementing the goal was similar in the order of importance that was, reliability in use was placed in the highest importance, followed by efficiency, except group 3. However, patterns related to satisfaction were achieving more than learnability due to many of the patterns related to satisfaction compare to learnability. In comparing the recommended patterns in the plan and the prototype designed, there were patterns that have been omitted while some have been added. We could assume that novice designers were not always referring to their planned pattern while designing and implementing their design.

Even though IG groups were only applied the 8 golden rules and were unaware of usability pattern, we reviewed their prototypes to capture any relevant usability pattern used for comparison. Using the same way of mapping usability pattern with the designed tasks as in group SG, we reviewed all prototypes from IG groups. All designed prototypes in IG groups were focused on the highest priority of usability goal which is reliability. Other usability goals were less emphasized such as efficiency of use was achieved the least in IG2 and no related pattern for learnability was applied in IG3. However, in overall, we found that the number of patterns applied in both groups were substantially difference. SG groups were apparently applying more usability patterns than IG groups.

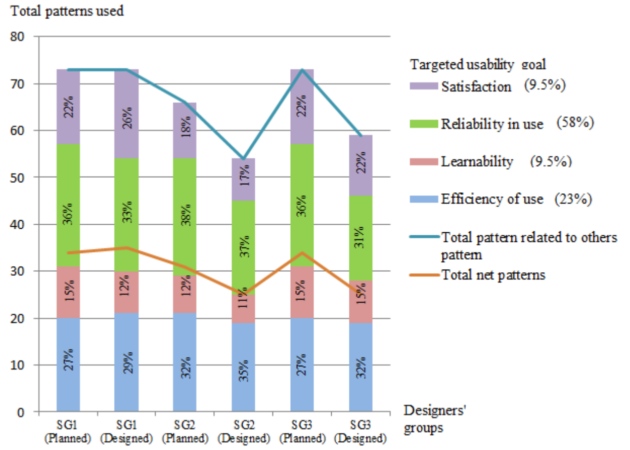

Fig. 3: Total and percentage of the use of usability patterns in prototype design for SGs' groups

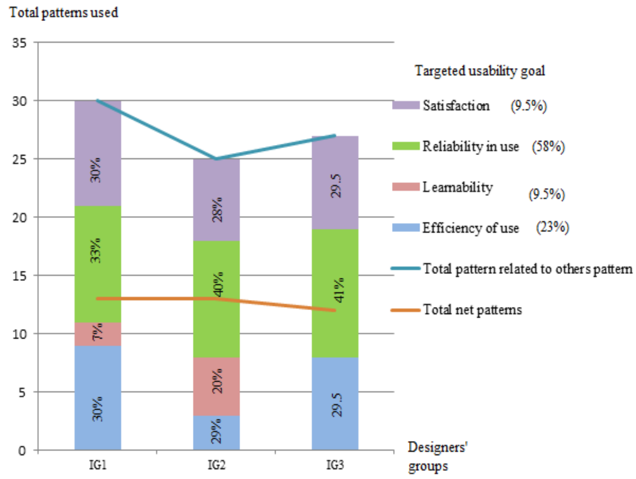

Fig. 4: Total and percentage of the use of usability patterns in prototype design for IGs' groups

5.3. Analysis of Prototype Evaluation and Selection

Figure 5 shows the overall flow of the prototype filtering selection process in the experiment. There were 6 and 4 prototypes evaluated by users and experts respectively. In the first step, we conducted quick usability testing with the users and thereafter applied the method of AHP to select the best prototype within the groups. We designed the experiment to allow users in each group to compare only 2 prototypes as it was easy to recall the comparison of the interaction experience rather than comparing 6 prototypes. Thus, 3 groups of users evaluated the designed prototype. Each prototype designed by the SG group was paired with an IG group for this comparative evaluation. The novice designers were briefed on conducting usability testing. They have been practiced on conducting usability test during the pre-testing day in order to familiarize with the steps and data to collect during user observation. The user's evaluation was conducted in a classroom-setting in parallel groups. The novice designers' peers were invited as surrogate users to perform usability testing in all pre-determined prototype designs based on the testing scenario in the observatory usability testing. Quantitative measures such as time taken to complete the tasks, errors made and comments from the users were also recorded.

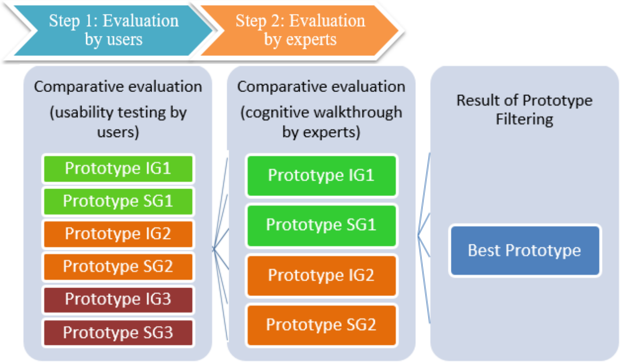

Fig. 5: Prototype filtering selection

Each prototype underwent usability testing on 6 designed functions (such as create 8 stationery items for test scenario 1 , create 5 users for test scenario 2, access low stock items for test scenario 3, send notification for collection for test scenario 4, making requisition for test scenario 5, and access requisition status for test scenario 6) for 6 users to measure its efficiency in completing the task, observe the users' error to measure its reliability and adapted 10 questions from System Usability Scale (SUS) from [60], [61] to measure its satisfaction, and survey question 7 (learn to use the designed system quickly) and question 10 (learn a lot of things prior to use the designed system) from SUS to measure the learnability. The total score for satisfaction and learnability were converted to 100 and 20 respectively. The result of all groups was summarized in Table 2.

Nevertheless, based on the usability measurements, novice designers may find difficult to decide which best prototype to select for further improvement due to the human performance measures were failed to show significant effect between the prototypes in the small sample size. These was also concurred with Mitta [30]. For example, comparative evaluation in usability testing conducted by group 3 on 2 prototypes for selection between SG3 and IG3, had showed total number of user's error (9 for IG3 and 8 for SG3), satisfaction score and learnability score were close to each other. The novice designers couldn't determine which prototype to select from the summary of the usability testing. Based on the given highest priority of usability goal it was reliability in use. Thus, both prototypes of IG3 and SG3 have 1 error different and do not show significance result. However, the result of user's performance measure showed prototype IG3 has better performance than prototype SG3. We extended the short usability testing to let the users to judge their decisions on the prototype selection using AHP. Similar to usability goal prioritized by 3 experts, we applied geometric mean of all individuals' judgement in the matrices and to get the weight preference of each prototype. Further discussion on the methodology in prototype selection also can be found in Hoo and Jaafar [62],[63]. The result of 6 user's perception in regards to the usability goals had showed prototype SG3 has higher total weight of user's preference than prototype IG3, with high relative weight for reliability in use in prototype SG3 (60%) compare to prototype IG3 (40%). Novice designers found the absolute quantitative result from the tool would assist them to determine which prototype users were preferred.

However, selecting the best prototype among the 6 was not conclusive as each group was comparing 2 prototypes only at one time. We conducted an overall filtering based on the insignificant result in comparative evaluation in usability testing and AHP technique, emphasizing the relevant usability pattern related to the determined priority of usability goal in design functions, and completeness of designed tasks. All comparative evaluation results were shown significant in AHP technique. We analyzed and concluded to select 4 prototypes. They were developed by IG group 1 and group 2 and SG group 1 and group 2 as all of them have usability patterns related to reliability more than other pattern goals. Prototypes developed by IG group 3 and SG group 3 were not selected as both designs did not give importance in the usability pattern related to reliability. Moreover, prototype SG3 was incomplete as some tasks did not have proper feedbacks to inform completion. Four selected prototypes were brought for expert evaluation to determine the best prototype.

Table 2: Summary of usability testing and comparative evaluation between IG and SG groups

Comparative prototype	Prototype1 (IG 1)	Prototype2 (SG 1)	Prototype1 (IG 2)	Prototype2 (SG 2)	Prototype1 (IG 3)	Prototype2 (SG 3)
Total weighted evaluation (AHP method)	0.282	0.718	0.538	0.462	0.415	0.585
Time performance in average seconds (Efficiency of use)	Scenario1: 209s Scenario2: 212s Scenario3: 39s Scenario4: 54s Scenario5: 79s Scenario6: 13s	Scenario1: 180s Scenario2: 82s Scenario3: 35s Scenario4: 73s Scenario5: 115s Scenario6: 21s	Scenario1: 176s Scenario2: 104s Scenario3: 6s Scenario4: 12s Scenario5: 112s Scenario6: 15s	Scenario1: 118s Scenario2: 100s Scenario3: 14s Scenario4: 4s Scenario5: 68s Scenario6: 14s	Scenario1: 44s Scenario2: 77s Scenario3: 5s Scenario4: 10s Scenario5: 64s Scenario6: 26s	Scenario1: 56s Scenario2: 105s Scenario3: 25s Scenario4: 18s Scenario5: 130s Scenario6: 32s
Number of errors (reliability)	Scenario1:4 Scenario2:1 Scenario3:3 Scenario4:2 Scenario5:0 Scenario6:0	Scenario1:0 Scenario2:0 Scenario3:1 Scenario4:1 Scenario5:0 Scenario6:1	Scenario1:0 Scenario2:0 Scenario3:0 Scenario4:0 Scenario5:2 Scenario6:0	Scenario1:3 Scenario2:2 Scenario3:2 Scenario4:1 Scenario5:2 Scenario6:0	Scenario1:2 Scenario2:2 Scenario3: 0 Scenario4: 2 Scenario5: 1 Scenario6: 2	Scenario1:1 Scenario2:0 Scenario3:1 Scenario4:0 Scenario5:3 Scenario6:3
Average SUS score (satisfaction)	57	71	66.25	68.75	79.6	80.8
Average score from SUS (Q7, Q10) (Learnability	13.5	14	14.6	15.8	16.7	15.8
Number of users' comments	Positive: 10 Negative:7	Positive: 12 Negative:3	Positive: 11 Negative:8	Positive: 10 Negative:5	Positive:13 Negative:2	Positive:15 Negative:2

The expert evaluation was conducted face-to-face, in a room-setting. Five field-experts from some private universities and five industry practitioners in software and design development were walkthrough the four selected prototypes with the test scenario and ended with their individual decision to make comparison for each prototype in each usability goal. Prototype 2 developed by SG group 1(SG1) achieved the highest in total weighted evaluation (0.3575) followed by SG group 2 (0.2270), IG group 1 (0.2140) and IG group 2 (0.2015), as shown in Figure 6. However, the rank between SG group 2, IG group 1 and IG group 2 were close to each other. These results were taken from 8 consistent experts' judgement on efficiency, 8 consistent experts' judgement on learnability, 9 consistent experts' judgement on reliability, and 7 consistent experts' judgement on satisfaction. All the 4 prototypes emphasized on pattern related to reliability in use and these also showed that the values were too close to each other in the result of experts' perception on reliability. However, prototype 2 has even better than other prototypes in terms of efficiency, learnability, and satisfaction that made it significantly different in its total weighted evaluation. Apparently, this could show that the quality of prototype that can be accepted by experts and better than using design approach if an approach that directs the use of usability pattern to the achievement of the targeted usability goal.

6. Conclusion

The developed method and tool had shown aggregation decision from experts to give direction to the novice designers in achieving usability goal in the system design. It provides a way to novice designers how trade-off of usability pattern is made in deciding the pattern used. However, guidance to select appropriate pattern needs to come from experienced designer. In deciding the best prototype fulfilling the usability goals in the evaluation process, the experiment had shown a collective decision both from prospective users and experts. It could give a clear decision of a particular prototype was chosen supported with the weight of preference for each usability goal. The comparison evaluation method here is not replacing usability evaluation, but a complement of usability evaluation to collectively determine the prototype design for next iteration. Quantifiable in the selection using AHP gives us a clear indication of how best the selected prototype was made. Aggregate of usability testing result based on time performance, number of user's rate error, satisfaction score may be found to be unreliable or similar result with the compared prototype as other human and environment factors such as typing skill, skill of observer or noise interruption, may influence the result. Comparison using AHP may bring the evaluators to think deeply which particular prototype is to be selected after interacting with prototypes. Collective quantifiable users' and experts' perceived result would possibly give convincing result. We expect the developed method could employ in the early stage of design process to improve the usability of a designed product. As future work, the empirical study could extend to investigate the quality of the prototype using the approach in terms of lesser number of iteration, and number of usability problems found.

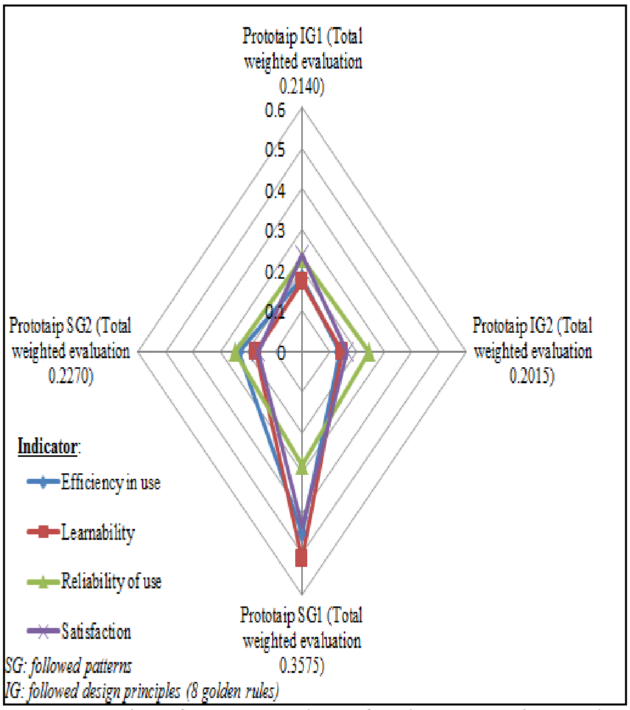

Fig. 6: Perception of experts' on the preferred prototypes in regards to usability goals

References

[1] Nielsen J (1992), The Usabilitv Engineering Life Cycle, *Computers*, vol. 25, no. 3, pp. 12–22.

[2] Jokela T, Koivumaa J, Pirkola J, Salminen P, & Kantola N, (2006), Methods for quantitative usability requirements: a case study on the development of the user interface of a mobile phone, *Personal and Ubiquitous Computing*, vol. 10, no. 6, pp. 345–355.

[3] Joshi A (2009), Usability Goals Setting Tool, *4th Workshop on Software and Usability Engineering Cross-Pollination: Usability Evaluation of Advanced Interfaces*, Uppsala.

[4] Joshi A & Sarda NL (2011), Do teams achieve usability goals? evaluating goal achievement with usability goals setting tool, in Human-Computer Interaction–INTERACT 2011, *Springer*, pp. 313–330.

[5] Hudson JM & Viswanadha K (2009), Can ' Wow ' Be a Design Goal ?, *Interactions ACM*, pp. 58–61.

[6] Chong CY, Lee SP, & Ling TC (2014), Prioritizing and fulfilling quality attributes for virtual lab development through application of fuzzy analytic hierarchy process and software development guidelines, *Malaysian Journal of Computer Science*, vol. 27, no. 1.

[7] Ji YG, Jin BS, Mun JS, & Ko SM (2007), Development of AHP Model for Telematics Haptic, in *Human Computer Interaction Part 1,LNCS* 4550, Springer-Verlag Berlin Heidelberg, pp. 517–526.

[8] Pearson JM, Pearson A, & Green D (2007), Determining the importance of key criteria in web usability, *Management Research News*, vol. 30, no. 11, pp. 816–828.

[9] Shrestha S, Abdinnour-Helm S, & Chaparro BS (2008), Using the Analytic Hierarchical Process to Create a Single Usability Score for Website Interfaces, *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, vol. 52, no. 16, pp. 1122–1126.

[10] Pilgrim C (2007), *User Goals and Web Site Navigation: Implications for the Design of Sitemaps*, Swinburne University of Technology, Faculty of Information & Communication Technologies..

[11] Ferré X, Juristo N, Windl H, & Constantine L (2001), Usability basics for software developers, *IEEE software*, vol. 18, no. 1, pp. 22–29.

[12] Seffah A & Metzker E (2009), On Usability and Usability Engineering, In: *Adoption-centric Usability Engineering*. London: Springer-Verlag London.

[13] Mostow J & Rey M (1985), Toward Better Models Of The Design Process, *AI magazine* 6.1, vol. 6, no. 1, pp. 44–57.

[14] Alan D, Janet F, Gregory A, & Russell B, Human-computer interaction (2004), England: *Pearson Education Limited*, pp.259-260.

[15] Schneiderman B, & Plaisant C (2010), Designing the User Interface- Strategies for Effective Human-Computer Interaction. Boston,MA: *Addison-Wesley*, pp.88-89.

[16] Nielsen J (1995), Ten usability heuristics for User Interface Design. Nielsen Norman Group, http://www.nngroup.com/articles/ten-usability-heuristics/. [Accessed December 19, 2013].

[17] Preece J, Sharp H, & Rogers Y (2012), Interaction Design-beyond human-computer interaction. *John Wiley & Sons*.

[18] Stone D, Jarrett C, Woodroffe M, & Minocha S (2005), User interface design and evaluation. *Morgan Kaufmann*.

[19] Johnson J (2007), GUI bloopers 2.0: common user interface design don'ts and dos. *Morgan Kaufmann*.

[20] Beck K & Cunningham W (1987), Using pattern languages for object-oriented programs, In *Proceedings of OOPSLA*, vol 87.

[21] Borchers J (2001), A pattern approach to interaction design, *AI & SOCIETY*, vol. 15, no. August 2000, pp. 359–376.

[22] Koukouletsos K, Khazaei B, Dearden A,& Ozcan M (2009), Teaching usability principles with patterns and guidelines, *IFIP International Federation for Information Processing*, vol. 289, pp. 159–174.

[23] Welie MV, Van Der Veer GC, & Eliëns A (2001), Patterns as Tools for User Interface Design, *Tools for Working with Guidelines*, pp. 313–324.

[24] Wesson J, Cowley L, Elizabeth P, Box PO, & Africa S (2003), Designing with Patterns : Possibilities and Pitfalls, in *Proceedings of the 2nd Workshop on Software and Usability Cross-Pollination: The role of Usability Patterns, INTERACT* 2003.

[25] Sun G, Yao S, & Carretero JA (2014), Comparing Cognitive Efficiency of Experienced and Inexperienced Designers in Conceptual Design Processes, *Journal of Cognitive Engineering and Decision Making*, vol. 8, no. 4, pp. 330–351, Jun. 2014.

[26] Ahmed S, Wallace KM, & Blessing L (2003), Understanding the differences between how novice and experienced designers approach design tasks, *Research in engineering design*, vol. 14, no. 1, pp. 1–11.
[27] Anwar R, Abidin SZ, & Hassan OH (2015), Understanding methodological solution in design situation of novice designer, in *International Conference on Interactive Collaborative Learning* (ICL), 2015, pp. 593–597.
[28] Rogers Y (2004), New Theoretical Approaches for HCI, *Annual review of information science and technology*, vol. 38, no. 1, pp. 87–143.
[29] Holzinger A (2005), Usability Engineering Methods for Software Developers, *Communications of the ACM*, vol. 48, no. 1, pp. 71–74.
[30] Mitta DA (1983), An Application of the Analytic Hierarchy Process: A Rank-Ordering of Computer Interfaces, *Human Factors: The Journal of the Human Factors and Ergonomics Society* , vol. 35, no. 1, pp. 141–157.
[31] Park KS & Lim CH (1999), A structured methodology for comparative evaluation of user interface designs using usability criteria and measures, *International Journal of Industrial Ergonomics*, vol. 23, pp. 379–389.
[32] Omar HM & Jaafar A (2011), AHP_HeGES: Tools to evaluate usability of educational computer game (UsaECG), *International Conference on User Science and Engineering* (i-USEr), 2011, IEEE, pp. 73–76.
[33] Kılıç Delice E & Güngör Z (2009), The usability analysis with heuristic evaluation and analytic hierarchy process, *International Journal of Industrial Ergonomics*, vol. 39, no. 6, pp. 934–939.
[34] Hoo MH & Jaafar A (2016), A Systematic Design towards Usability for Novice Designers, *TELKOMNIKA*, vol. 14, no. 2, 2016.
[35] Dorst K (2008), Design research: a revolution-waiting-to-happen, *Design studies*, vol. 29, no. 1, pp. 4–11.
[36] Gasson S (2003), Human-centered Vs. User-centered Approaches to Information System Design, *Journal of Information Technology Theory and Application*, vol. 5, no. 2, pp. 29–46.
[37] Hillier B, Musgrove J, & Sullivan PO (1972), Knowledge and design, *Environmental design: research and practice*, vol. 2, pp.1–3.
[38] Fore D, Goldenhar LM, Margolis PA, & Seid M (2013), Using goal-directed design to create a novel system for improving chronic illness care, *JMIR research protocols*, vol. 2, no. 2.
[39] Kerr SJ, Tan O, & Chua JC (2014), Cooking personas: Goal-directed design requirements in the kitchen, *International Journal of Human-Computer Studies*, vol. 72, no. 2, pp. 255–274.
[40] Granlund A, Lafreniere D, & Carr DA (2001), A Pattern-Supported Approach to the User Interface Design Process, *in Proceedings of HCI International 2001, 9th International Conference on Human-Computer Interation*, pp. 1–5.
[41] Welie MV & Trætteberg H (2000), Interaction patterns in user interfaces, in *7th. Pattern Languages of Programs Conference*, pp. 13–16.
[42] Thongmool G. & Phankokkruad M (2014), Analysis of interaction user interface patterns and usability study in computer assisted instruction for Tablet PC, *IEEE International Conference in Control System, Computing and Engineering (ICCSCE)*, pp. 472–477.
[43] Borchers J (2002), Teaching HCI design patterns: Experience from two university courses, in *Patterns in Practice A Workshop for UI Designers at CHI 2002 International Conference on Human Factors of Computing Systems*, pp. 2005–12.
[44] Lockton D, Harrison D, & Stanton NA (2013), Exploring design patterns for sustainable behaviour, *The Design Journal*, vol. 16, no. 4, pp. 431–459.
[45] Zou F, Hua Q, Wang X, & Guo L (2014), Design for multiple-user interfaces with usability patterns, *in Computer Science and Applications: Proceedings of the 2014 Asia-Pacific Conference on Computer Science and Applications* (CSAC 2014), Shanghai, China, 27-28 December 2014, 2015, pp. 389–392.
[46] Kotzé P, Renaud K, Koukouletsos K, & Dearden A (2006), Patterns , Anti-Patterns and Guidelines – Effective Aids to Teaching HCI Principles ?,*Proc. of The First Joint BCS/IFIP WG13. 1/ICS/EU CONVIVIO HCI Educators' Workshop*.
[47] Tidwell J (2010), Designing Interfaces. *O'Reilly Media*, Inc.
[48] Tidwell J (1998), Interaction design patterns, in *Conference on Pattern Languages of Programming*.
[49] The Usability Group at the University of Brighton, The Brighton Usability Pattern Collection. http://www.cmis.brighton.ac.uk/research/patterns/home.html Revised February 1999. Accessed Novermber 10, 2013.
[50] Perzel K & Kane D (1999), Usability patterns for applications on the world wide web, in *PloP'99*.
[51] Folmer E & Bosch J (2004), Architecting for usability : a survey, *The Journal of Systems and Software*, vol. 70, pp. 61–78.
[52] Saaty TL (1980), The Analytic Hierarchy Process. New York: *McGraw Hill*.
[53] Saaty TL (2008), Decision making with the analytic hierarchy process, *International Journal of Services Sciences*, vol. 1, no. 1, p. 83.
[54] Saaty TL & Islam R (2015), Hierarchon Vol 2: A dictionary of AHP Hierarchies, *RWS Publications*.
[55] Saaty TL (1980), The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation, *McGraw Hill International*.
[56] Hoo MH & Jaafar A (2015), Novice Assistance Tool and Methodology: Design Decision and Task-Pattern Mapping, *Proceeding of the Electrical Engineering Computer Science and Informatics*, vol. 2, no. 1.
[57] Welie MV, Van Der Veer GC, & Eliëns A (2001), Patterns as Tools for User Interface Design, in *Tools for Working with Guidelines*, Springer London, pp. 313–324.
[58] Folmer E, Gurp JV, and Bosch J (2003), A framework for capturing the relationship between usability and software architecture, *Software Process: Improvement and Practice*, vol. 8, no. 2, pp. 67-87.
[59] Pattern Factory, Patternry: Start building consistent web interfaces. http://patternry.com. Revised November 2013. Accessed January 19, 2014.
[60] Brooke J (2013), SUS: a retrospective, *Journal of Usability Studies*, vol. 8, no. 2, pp. 29–40, 2013.
[61] Brooke J (1996), SUS-A quick and dirty usability scale, *Usability evaluation in industry*, pp. 189–194.
[62] Hoo MH & Jaafar A (2014), Goal prioritization and preliminary usability evaluation: An approach to assist novice designer, *Journal of Theoretical and Applied Information Technology*, vol. 67, no. 3, pp. 690–700.
[63] Hoo MH & Jaafar A (2013), An AHP-based approach in the early design evaluation via usability goals, In *International Visual Informatics Conference*, Springer International Publishing, pp. 694-706.