Measuring Helpfulness of Personal Decision Aid Design Model

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***Abstract*-The existence of countless computerized personal decision aids has triggered the interest to investigate which decision strategy and technique are ideal for a personal decision aid and how helpful is decision aid to non-expert users? Two categories of decision strategies have been reviewed; compensatory and non-compensatory, which results in fusing the two strategies in order to get the best of both worlds. Findings from the study of focus groups show that multi criteria decision method (MCDM) known as Pugh matrix and lexicographic have been identified as two most preferred techniques in solving personal decision problems. Both, the strategies and techniques, are incorporated in the development of a personal decision aid design model (PDADM). The proposed model is then validated through prototyping method in two different case studies (choosing development methodology in mobile computing course; and purchasing a mobile phone). In measuring the helpfulness of the prototypes, this study is looking at four dimensions; reliability, decision making effort, confidence, and decision process awareness. The findings show that the respondents from different decision situations perceived PDADM driven prototypes as helpful.**

Keywords-Computerized decision aid, decision strategy, multi criteria decision method, helpfulness

I. INTRODUCTION

Human commonly makes decisions of varying importance on daily basis, thus, making the idea of seeing personal decision making as a researchable matter seems odd. However, studies have proven that most humans are much poorer at decision making than they think. An understanding of what decision making involves, together with a few effective techniques, will help produce better decisions. Thus, explains the existence of decision support technology at different levels in various fields; for instance in management, engineering and medicine.

To date, the attentions given to the improvement of decision support at organization level has been enormous. On the contrary, the study in improving the performance of decision aid in personal decision making is still lacking and out of date (Jungermann, 1980; Wooler, 1982; Bronner & de Hoog, 1983; Alidrisi, 1987; Todd & Benbasat, 1991). The existence of countless computerized personal decision aids (either in the form of website, software or spreadsheet) these days, has triggered the interest to investigate the suitability and helpfulness of this technology to users, especially to the non-expert users.

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II. BACKGROUND OF STUDY

Although most personal decisions made are minor in nature and in terms of its consequences, but still, being able to make an actual decision out of any situation is indeed essential (Rich,1999). Living in the 21st century, it is almost impossible not to associate anything with computer technology and this includes decision making. The evidence of human limitations in information processing is unquestionable, thus, the advantage of computerized decision aids can be a major benefit for decision maker.

A. Research Problem Statement

Decisions are part of human life. Decision majorly involves choices, and the hardest part is to make the right choice. It can be demanding to choose without being clear about what to choose and how to go about it, which later, may lead to being indecisive. Moreover, indecisiveness may cause failed actions and tendency of being controlled by others (McGuire, 2002; Arsham, 2004). This shows that, under appropriate circumstances, it is essential to apply decision aid in making decision.

Over decades, there are countless of studies on decision support technology that proposed the methods of improving the performance of such technology at organization level. However, in more recent years, the existence of computerized personal decision aids (more examples and reviews in section 3.2) are mushrooming and progressively getting attention from users; for example like "hunch" (www.hunch.com) and "Let Simon Decide" (www.letsimondecide.com). This shows the relevance of study in issues related to computerized decision aids pertaining to personal decisions.

For more than five decades, most of research that have been carried out on decision process focuses either only on descriptive aspect (studying how decisions are being made) or normative aspect (studying how some ideally logical decider would make decisions). Decider in this context is referring to decision aid. Prescriptive research on decision processes, on how to help the decider progress from the descriptive to the normative has, however, been scarce (Brown, 2008). This is also has been mentioned earlier in (Bell et al., 1988).

The term computerized decision aid refers to a very diverse set of tools based on a varying techniques and complexity. Generally, decision aids are designed with aims to help human choosing the best decision possible with the knowledge they have available. However, creating effective decision aids is more than meet the eyes (Power, 1998). Complex and structured mathematical techniques that correspond to the uncertainty of a decision situation have long held great theoretical appeal for helping decision makers make better decisions. Studies by Hayes and Akhavi (2008), Adam and Humphreys (2008), Zannier et al., (2007) and Law (1996) do not agree with the earlier statement. Hayes and Akhavi (2008) also affirmed that *"decision aids based on mathematically correct and sophisticated models do not actually improve the decision making performance. This is due to how the decision aids frame the problem in a way that does not fit human decision making approaches"*. Furthermore, although uncertainty can be tackled using complex mathematical tools, but more often than not, decision maker will not have the time to implement the structured mathematical strategies (McGuire, 2002; Arsham, 2004). These are further supported in Alidrisi (1987) and Adam and Humphreys (2008). All the researchers agreed that as far as personal decision making is concerned, complex and structured mathematical techniques are not preferred. Evidently, this indicates that a simple decision making model is a more needed solution when compared to the rigorous criteria weighing analysis.

All else being equal, decision makers prefer more accurate and less effortful choices. Since these desires are conflicting, thus selecting suitable strategy for the aid strategy can be a tricky task (Payne, 1993; Naude, 1997; Al-Shemmeri et al., 1997; Zanakis *et al.*, 1998). Then again, the appropriate use of decision strategies can contribute to effective decision making (Cosier & Dalton, 1986).

B. Research Objectives

With the nature of the problem in mind, this study aims to propose a personal decision aid design model that is perceived helpful. The following specific aims are outlined in means to support the general aim:

i. To identify the appropriate decision strategy and decision technique for personal decision making
ii. To incorporate identified decision strategy and technique in the development of the personal decision aid design model
iii. To validate the personal decision aid design model in different situations via prototyping method
iv. To measure the users' perceived helpfulness of the prototypes

III. Introduction to Decision Techniques

Apparently, a working knowledge of decision theory is needed before embarking into developing a decision aid design model. The design of the model includes two important expectations which are to accomplish a better decision and ensuring the helpfulness of the model via prototyping method.

Among the topics reviewed from the literatures include decision making, multi criteria decision making (MCDM) methods, computerized decision aids, related decision theories, and aspects of helpfulness of information systems in general and decision support in particular.

A. Decision Strategies and Techniques

Personal decision normally involves evaluation of many choices and making selection out of many. Generally, there are various strategies and techniques in making decision. This study focuses on decision making problems when the number of the criteria and alternatives is finite, and the alternatives are given explicitly. Problems of this type are called multi attribute decision making problems.

Compensatory and Non-compensatory Strategies

The decision strategies are commonly divided into two broad categories, non-compensatory and compensatory. Ullman (2002) defines non-compensatory strategies using the example of one well documented non-compensatory strategy; the lexicographic method.

As for compensatory strategies, Ullman (2002) defines it as strategy which allows decision makers to evaluate the alternatives by balancing the strong features of the alternatives with its weaker features. Example of methods that support compensatory strategy is decision matrix and utility theory methods.

Lexicographic method

In the lexicographic method, criteria are ranked in the order of their importance. The alternative with the best performance score on the most important criterion is chosen. If there are ties with respect to this criterion, the performance of the tied alternatives on the next most important criterion will be compared, and so on, till a unique alternative is found (Linkov *et al.*, 2004).

Maut

Multi-attribute utility theory (MAUT) is seen as an ideal approach for personal decision making by many previous researchers due to the nature of the decision problem. This is supported in a number of studies (Bronner & Hoog, 1983; Alidrisi, 1987; Işıklar & Büyüközkan, (2007); Adam & Humphreys, 2008). In a study, Adam and Humphreys (2008) described that, *"MAUT is simple enough to implement as compared to other model of decision making which requires a more rigorous criteria weighing analysis that is not necessarily needed for the role of decision making"*.

Pugh's Method

Pugh's method is known as the simplified MAUT which was first introduced by Pugh (1990) as the method for concept selection in engineering decision. In Pugh approach, all alternatives are compared to a datum alternative on each criterion. Alternatives are either better (+1), worse (-1), or the same (0) as the datum for a given criterion. The score for each alternative is calculated as the number of occurrence of (+1) minus the occurrence of (-1). Emphasis was placed on using these comparisons to try to improve the weaknesses (i.e., the –1's) of an alternative without weakening any strength (i.e., +1's).

Weighted Decision Method

Weighted decision matrix involves mathematical reasoning in solving single or multi attribute decision problems. Two examples of weighted decision matrix are Weighted Sum Model (WSM) and Weighted Product Model (WPM). WSM is probably the most widely used approach, especially in single dimensional problems (Triantaphyllou, 2000). If there are *m* alternatives and *n* criteria then, the best alternative is the one that satisfies the following expression (Fishburn, 1967):

$$A^*_{WSMscore} = \max_i \sum_{j=1}^{n} a_{ij} w_j$$, for i = 1, 2, 3 …m

WPM shares almost similar concept with WSM. The main difference is that instead of addition in the model there is multiplication. Each alternative is compared with the others by multiplying a number of ratios, one for each criterion. Each ration is raised to the power equivalent to the relative weight of the corresponding criterion. In general, in order to compare two alternatives A_K and A_L, the following product has to be calculated according to this expression (Bridgman, 1992; Miller & Star, 1969):

$$R(A_K \mid A_L) = \prod_{j=1}^{n} \left(a_{Kj} \mid a_{Lj}\right)^{w_j}$$,

where n is the number of criteria, aij is the actual value of i-th alternative in terms of j-th criterion, and wj is the weight of importance of the j-th criterion. If the term R (AK|AL) is greater than or equal to one, then it indicates that alternative AK is more desirable than alternative AL. The best alternative is the one that is better than or at least equal to all other alternatives.

Analytic Hierarchical Process

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making approach and was introduced by Saaty (1977 and 1994). The AHP has attracted the interest of many researchers mainly due to the careful mathematical properties of the method and the fact that the required input data are rather easy to obtain. The AHP is a decision support tool which can be used to solve complex decision problems. It uses a multi-level hierarchical structure of objectives, criteria, sub-criteria and alternatives.

Pros and Cons Analysis

Pros and Cons Analysis is a qualitative comparison method in which good things (pros) and bad things (cons) are identified about each alternative. Lists of the pros and cons, based on the input of subject matter experts, are compared one to another for each alternative. The alternative with the strongest pros and weakest cons is preferred. The decision documentation should include an exposition, which justifies why the preferred alternative's pros are more important and its cons are less consequential than those of the other alternatives. Pros and Cons Analysis is suitable for simple decisions with few alternatives and few discriminating criteria of approximately equal value. It requires no mathematical skill and can be implemented rapidly (Baker *et al.*, 2002).

B. Computerized Personal Decision Aids

A number of computerized decision aids have been identified. The aids come in varying mediums like website, spreadsheet, software and web application. All of the identified aids can be used to assist in personal decision making and also in other type of decision problems like financial and management problems. Table 3.1 summarizes eight computerized decision aids along with the reviews. The number of aids reviewed in this study is meant to be representative.

Table 3.1: Computerized decision aids

	Decision aid	***Type***	***Method/ Technique***	***Description***	***Reviews***
1)	Hunch (2009) (www.hunch.com)	Decision engine (web)	Collective intelligence decision making, machine learning & decision trees	• A decision community website • uses machine learning based on statistical inferences (the system gets smarter as more users use it) • uses question selection algorithm to a) find a question which will discriminate well among the remaining possible recommendation outcomes for user b) looks for a question which can help optimize and rank the remaining recommendation outcomes to present you with the ones you'll like the most	• the interactivity is intuitive but involves series of steps (answering questions) • Involves a lot of statistical analysis in the back end (very complex) • Does not involve defining importance of criteria (rank the criteria)
2)	Let Simon Decide (2009) (www.letsimondecide.com)	Decision engine (web)	Collective intelligence decision, weighted decision analysis	• consists of three decision making tools: a. *My Scores*: for logical, fact based decision with multi-alternatives b. *My Life Match*: for big, life-changing decisions	• involves complex mathematical approach to decision-making • requires many steps

				c. *My Points of View*: for quick decision • combines user qualitative input with a weighted, mathematical formula (weighs alternatives against proprietary profile) • enables collective learning – share decision summary with others • provides action plan for every decision	although the process is intuitive
3)	Choose It! (1999) (chooseit.sitesell.com/)	Web application	Decision Matrix	• Online decision making tool that use decision matrix concept • can be used to make important business, financial, and personal life decisions	• does not acknowledge the distinct difference between subjective and objective factors
4)	Management For The Rest of Us (MFTROU.com) Decision Making Tool (n.d.) (www.mftrou.com/decision-making-tool.html)	Spreadsheet	Decision Matrix	• based on classic decision grid concept • in Excel spreadsheet format which contains: a. Overview of how to make decisions b. Decision Making Example c. Template for Making Your Own Decision	• crowded text in the visual presentation • Very formal presentation (in excel environment)
5)	Decision Oven (2008) (decisionoven.com/)	Software	Decision matrix with mathematical reasoning	• Off the shelf decision support software • can be used to support personal or business decisions	• acknowledge the difference between defining subjective criteria and objective criteria
6)	EduTools Decision Engine (2009) http://ocep.edutools.info/summative/index.jsp?pj=4	Web application	Weighted decision matrix	• use a rational decision making process	• Only focus on selecting a course management system, not for generic decision • User have to be familiar with the products and features that they wish to compare
7)	Career Decision Making Tool (CDMT) (n.d.) (http://cte.ed.gov/acrn/cdmt/tool.htm)	Instructor-led, classroom-based online tool	Guidelines and teaching/learning material	• It's a career decision making tool • It suggests the following decision cycles: a) Engaging b) Understanding c) Exploring d) Evaluating e) Acting f) Reflecting	• Only focus on career decision making, not for generic decision • To be implemented in teaching/learning environment
8)	Super Decisions (2004) http://www.superdecisions.com/	Software	Analytic Network Process	• It extends the Analytic Hierarchy Process (AHP) • Uses same fundamental prioritization process based on deriving priorities through judgments on pairs of elements or from direct measurements.	• Use complex decision analysis with rigorous mathematical reasoning • Solve for complex decision problem

C. Theories in Modeling Decision Aid Process

Decision theory is an attempt to explicate how human make decision, and in helping us understand the process of decision making. A grasp of the fundamentals of decision making is crucial to the effective design of the decision aid. Therefore, this study discusses a number of related theories that contribute to understanding multi criteria decision making. The related literature is summarized in Table 3.2.

Table 3.2: Literature survey of related decision theories

Decision Theories	References
Multi Attribute Utility Theory	Baker et al. (2001); Alidrisi (1987); Dyer et al. (1992); Keeney & Raiffa (1993); Collins et al. (2006)
Behavioral Decision Theory	Einhorn & Hogarth (1981); Westaby (2005)
Bounded Rationality Model	Bahl & Hunt (1984); March & Simon (1958); Newell & Simon (1972)
Implicit Favorite Model	Bahl & Hunt (1984); Soelberg (1967)
Dominance Theory	Easwaran (2007); Zsambok et al. (1992)
Satisficing Theory	Zsambok et al. (1992); Simon (1956)

IV. Research Methodology

This study employed design science approach to address the research questions posed earlier. The selection of a suitable approach is based on the nature of a research, phases involved and research outcomes. March and Smith (1995) described design science research as a process which aims to *"produce and apply knowledge of tasks or situations in order to create effective artifacts"* in order to enhance practice.

In general, process in design science research can be structured into three main phases include "problem identification", "solution design" and "evaluation". Clearly, design science research consists of a series of steps but in practice they are not always executed in sequence; they often are performed iteratively. This study implemented the following steps, adapted from Offermann *et al.* (2009), and driven by design science research approach.

A. Problem Identification

The phase is divided into the following steps: "identify problem", "literature research" and "expert interviews". It specifies a research question and verifies its practical relevance. As a result of this phase, the research questions are defined.

Identify Problem

The existence of countless computerized personal decision aids, these days, has triggered the interest to investigate the relevance and helpfulness of ICT assistance in personal decision making. Offermann et al. (2009) provides the support for the identification of research problem in this study, of which, they stated that researchable material "may arise from a current business problem or opportunities offered by new technology".

Literature Search

In order to identify the research problem, literature search is used. As a summary, a number of decision strategies, decision techniques (MCDM methods), computerized personal decision aids, and decision making related theories were reviewed in this study. This results in strengthening the needs for a solution to propose a proper decision making model for personal decisions.

Expert Interview

Interviews with experts in the related field were conducted to identify relevancies of the addressed problems. Discussion with the experts involves brainstorming of idea, approval of idea and reviews on research material. Three experts have been referred to during this stage and also at certain stage of this study. The experts are professors and academics specializing in one of these fields: model-based systems and qualitative reasoning, quantitative analysis; and artificial intelligence.

B. Solution Design

In the second phase, the solution is designed and proposed. After identifying the research problems and evaluating its relevance, a solution is developed in the form of artifacts. Varying methods are used to come out with all the artifacts including content analysis, expert review, focus group study, participatory design, prototyping and elicitation work.

C. Evaluation

In this study, evaluation is achieved by the mean of case studies and laboratory experiments. The findings of this stage are further explained in Result section.

V. Development of Personal Decision Aid Design Model (PDADM)

This section describes the process in developing the PDADM. Prior to this, an appropriate decision strategies for personal decision making need to be identified, and followed by a selection of appropriate decision technique (i.e. MCDM method). Afterward, both will be incorporated in the development of the decision aid design model. The method used in developing PDADM involves content analysis, participatory design and expert review.

A. Decision Strategy Selection

From the literature search, two common decision strategy groups are studied; non-compensatory and compensatory. Findings indicate that non-compensatory strategies do not allow very good performance relative to one criterion to make up for poor performance on another. In other words, no matter how good an alternative is, if it fails on one evaluative criterion, it is eliminated from consideration.

As for compensatory strategies, they allow the decision makers to balance the good features of an alternative with its weaker features. Additionally, the compensatory strategies give greater accuracy in decision but the non-compensatory strategies take the least time to accomplish decision.

In responding to the earlier discussion, this study decided to combine the implementation of compensatory and non-compensatory strategies in order to obtain the "best of both worlds". This is supported by Ullman (2002) in his work which stated that *"a method that gives the accuracy of the compensatory strategy with the effort of the non-compensatory strategy would add value to human decision making activities"*.

B. Decision Technique Selection

In light of the numerous decision techniques available to decision makers, study of focus groups is used in order to get some understanding of which kind of techniques that is more preferred by the (non-expert) decision maker. This study also decided that introducing more than one would enhance focus groups abilities to understand that there is not a single right way to resolve a decision.

There are five techniques that were introduced to the focus group of 51 (non-expert) participants of varying demographic background; weighted sum method (WSM), Pugh matrix (PUG), Analytic Hierarchy Process (AHP), pro and cons analysis (PCA), and lexicographic (LEX). All methods involve defining criteria on which to compare a set of alternatives. The group was encouraged to solve the same decision scenario (choosing a laptop from 4 different brands) using each or at least three of the techniques mentioned above one at a time. This study did not make it compulsory for them to use all the techniques, because of varying rate of understanding of the techniques after first time being introduced to them. Hence, unutilized techniques show respondents' difficulty to understand and to get familiar with it.

After establishing the focus group previous experience with each decision technique, the group was asked which technique helped the most and which they had more confidence in. Next, the group was asked which tool they think is "least prone to bias".

The results from the survey are summarized for each question. The first two questions concerned (i) which technique that they think helped the most if they were to use it in real decision and (ii) which technique they had the most confidence in. As shown in Table 5.1, technique PUG and LEX scored among the highest number of respondents for both questions.

Table 5.1: Helpful and Confidence

	WSM	**PUG**	**AHP**	**PCA**	**LEX**
Helpful	21	39	3	19	43
More confidence in	14	31	3	15	45

The next question asked the group which technique they felt was least prone to bias (that is, is the most difficult to manipulate to achieve preconceived results). These results are shown in Table 5.2.

Table 5.2: Bias

	WSM	***PUG***	***AHP***	***PCA***	***LEX***
Least prone to bias	34	41	2	18	22

Interestingly, even though majority of the participants had more confidence in LEX, the score changes when it comes to biasness of the technique. More than half of them felt that PUG was less prone followed by second the highest scored technique; the WSM. Nevertheless, the participants noted that it would take even more time and effort to achieve decision with the PUG and WSM. It is noted that AHP scores the lowest response for all three questions, which is due to refusal of most respondents to utilize it. Evidently, from this focus group study, PUG and LEX are selected as the potential techniques to be incorporated in the design of proposed personal decision aid design model.

PUG or Pugh matrix is originally a concept selection method used by engineers for design decision (Pugh, 1990). Since it was introduced, there have been many different modified versions of Pugh matrix analysis in various examples of its applications. In line with this, a participatory design study was conducted to learn which implementation of the Pugh matrix is preferred and suitable with the non-expert decision is making style. There are five versions (see Appendix) of Pugh matrix approach (including the original) used in this participatory design study. A total of 66 participants of varying demographic background were involved in this study.

Firstly, the participants were briefly explained about the different implementations of the Pugh matrix method. Then, they were asked to solve a designated decision problem (choosing a laptop from four different brands) using all four versions; one at a time. Later, the participants were asked ten questions (refer Table 5.3) based on their experience using the different implementation of Pugh matrix and also three additional demographic questions on gender, IT skill and age.

Table 5.3: Questions asked in the participatory design study

No.	Question
Q1	Are you familiar with the use of Pugh matrix?
Q2	Do you find it difficult to choose the first reference?
Q3	Do you prefer to weigh or not to weigh the criteria?
Q4	Do you prefer to use percentage (%) or scaled values (e.g. 1 to 5) as weight?
Q5	Do you prefer to use comparative symbols (+, -, S) or scaled values (e.g. 1 to 5) to rate the alternatives?
Q6	Which version of Pugh matrix do you think is most helpful?
Q7	Which version of Pugh matrix you had more confidence in?
Q8	In your opinion, which version is least prone to bias?
Q9	Would you use either of these Pugh matrix approach in your real life decision?
Q10	Would it be easier if Pugh matrix process is automated (i.e. in a computerized format)?

All the responses from participants were recorded and summarized in the following tables (Table 5.4 to 5.12). The first question dealt with the previous experience of the participants with Pugh matrix method. As shown in Table 5.4, majority of the participants had not used the Pugh approach before this study.

Table 5.4: Familiar with Pugh matrix

	Yes	*No*	*NA**
Familiar?	9	57	0

**=No answer*

The next question asked about participants experience during the study when they were required to choose their own reference for comparative analysis in Pugh matrix take place. As shown in Table 5.5, more than half of the participants claimed that it is not a problem for them to perform that task. But the number of participants who claimed the opposite was not far behind.

Table 5.5: Difficulty to choose first reference

	Yes	*No*	*NA*
Difficult?	24	42	0

The third and fourth questions asked about participants experience with the use of weight in defining the importance of each of the evaluative criteria. As shown in Table 5.6, majority of the participants preferred to weigh their criteria during the process. From this majority group, 35 of them preferred weighing the criteria using scaled values than using percentage (Table 5.7). This number represented more than half of the participants.

Table 5.6: Weighing criteria

	Yes	*No*	*NA*
Weighing criteria	42	21	3

Table 5.7: Use percentage or scaled values for weighing

	Percentage	*Scaled Values*	*NA*
Preferred weighing criteria	26	35	5

The fifth question asked the participants if they prefer to use symbols; + for better, - for worse and + for equal); or scaled value to perform the comparative analysis of alternatives against the reference on each criterion. Majority agreed that the use of symbols is more convenience for the comparative analysis.

Table 5.8: Use symbols or scaled values

	Symbols	*Scaled Values*	*NA*
Preferred evaluation styles	52	12	2

The next two questions (question 6 and 7) dealt with participants experience after using the Pugh approach to solve the decision problem. As shown in Table 5.9, the obviously dominant choice for both questions is the original version. The participants, as a whole, not only felt like the original version helped the most in assisting them with decision problem, but they had more confidence in it.

Table 5.9: Helpful and confidence

	Original	*MV1*	*MV2*	*MV3*	*MV4*	*NA*
Helpful	22	11	13	7	8	5
More confidence in	21	10	14	8	10	3

MV=modified version

Even though majority has more confidence in the original version, but when asked about which version they think is least prone to bias, the majority score shows contrasting response. One third of the participants agreed MV2 (modified version #2) is the one least prone to bias.

Table 5.10: Bias

	Original	*MV1*	*MV2*	*MV3*	*MV4*	*NA*
Least prone to bias	15	11	22	10	4	4

Concerning the use of Pugh approach in real decision situation, 49 of 66 indicated that they will consider using this approach, 16 indicated that they would not, and one did not respond to this question (refer Table 5.11).

Table 5.11: Will use Pugh matrix in real situation

	Yes	*No*	*NA*
Will use Pugh approach in real situation?	49	16	1

Lastly, when asked whether the participants think that by automating the process of Pugh matrix (in computerized format) will make it easier to use this approach, majority of them answered yes. From 12 of the remaining participants who answered no, 7 of them appeared to claim themselves as having very less IT skill.

Table 5.12: Automate Pugh matrix

	Yes	*No*	*NA*
Automating Pugh approach makes it easier?	54	12	0

(5)

C. Incorporating the Decision Strategy and Decision Technique in PDADM

The results; decision strategies and techniques, obtained from previous focus group study are incorporated in the development of personal decision aid design model. The model comprises of the flow of the decision process and the relationship between input and outcome of each step of the process. Figure 5.1 illustrates the previous statement clearer.

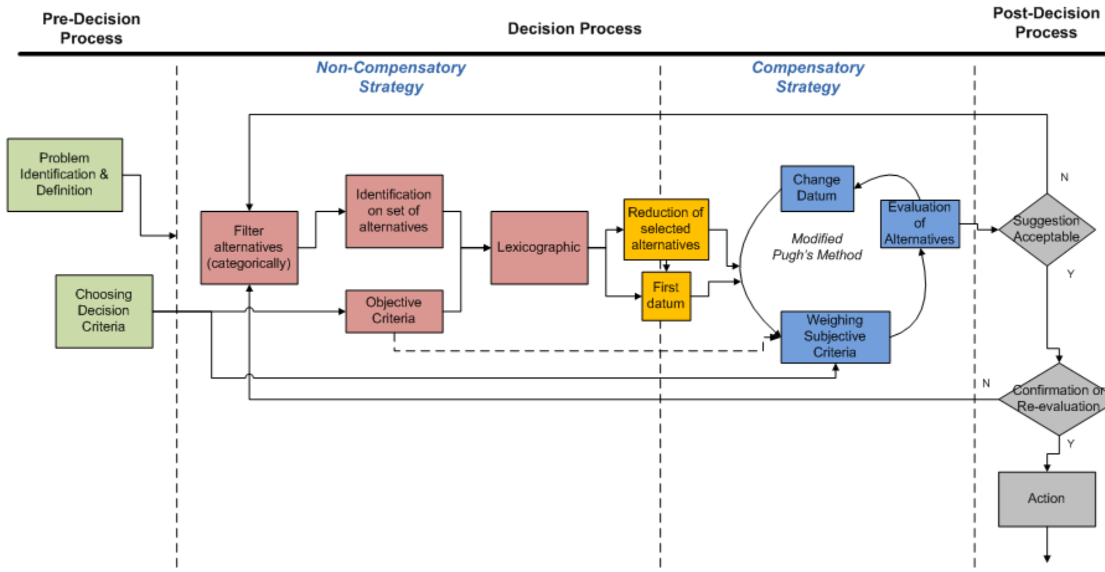


Figure 5.1: Personal Decision Aid Design Model (PDADM)

VI. Implementing PDADM in Different Situations

The proposed PDADM is validated through development of two prototypes in two different case studies; choosing development methodology in mobile computing course; and purchasing a mobile phone. These case studies involved two very different decision situations which were intended to showcase the flexibility and functionality of the proposed model.

A. Case study 1: Choosing a Development Methodology in Mobile Programming Course

Over the last decade, mobile computing has received significant interest in the academic and industrial research community. As a result, demands from the industry for graduates of mobile computing course are rising (Gillespie, 2007).

The graduates who are entering the mobile development world are expected to put up with the challenges imposed by the mobile environment. Heyes (2002) reported that mobile developers face twice as much as challenges than developing traditional system application due to the specific demand and technical constraints of mobile environment. In addition to that, inadequate research in assisting developers with the mobile development issues is also highlighted in the GI Dagstuhl Research Seminar in 2007 (König-Ries, 2009). Within this perspective, it is believed that selecting a suitable development methodology is the key to these issues. The use of a methodology is important, as a project can be structured into small, well-defined activities where the sequence and interaction of these activities can be specified (Avison & Fitzgerald, 1990). Hence, students should be exposed to the importance of adopting a suitable methodology for a mobile development project.

development project is another challenge in itself (Bertini *et al.*, 2006; Heikkinen & Still, 2005; Atkinson & Olla, 2004; Heyes, 2002; Afonso *et al.*, 1998). Less experienced developers will find the task even more challenging, thus, this study seeks to propose a solution by implementing the proposed PDADM via a development of prototype named as m^d-Matrix (as in mobile development methodology matrix).

Features and Screenshots of m^d-Matrix

This decision-making tool is mainly aimed at assisting developers (especially the novice) in choosing the most appropriate development methodology for mobile development project. The numbers of available development methodologies in md-Matrix are meant to be representative; only for the purpose of demonstrating the decision process that occur in selecting a mobile development methodology. The prototype of md-Matrix features the following (see Table 6.1):

Table 6.1: Features of m^d-Matrix

m^d-Matrix	
Alternatives filter	Mobile application technologies: Generic J2ME* Flash Lite* Native Web based Object Oriented Platform dependent
Criteria	12 objective 12 subjective
Alternatives	Flash Lite (4 methodologies) J2ME (4 methodologies)
Feedback	Pop-up window On screen text Interface agent

** enabled in this prototype*

The first step of m[d]-Matrix enables user to filter the available methodologies based on preferred technology for development of a mobile application (Figure 6.1). As it proceeds with the second step (Figure 6.2), users will make their selection of narrative criteria to further filter the options (methodologies) following the non-compensatory strategy (lexicographic process). The three highest scored methods (see Figure 6.3) which pass most of the selected criteria will be ranked accordingly and the one in the highest rank will be set as the first reference (datum). Next, the three identified methods from previous step will be compared to each other following the compensatory strategy (modified Pugh's method) based on preferred subjective criteria (Figure 6.4). The steps can be iterated in maximum 3 cycles where in each round the reference will be changed until each methodology will be a reference once. The dominance methodology from the 3 rounds will be suggested as the best selection. The following are screenshots of m[d]-Matrix:

Figure 6.1: Alternatives filtered categorically

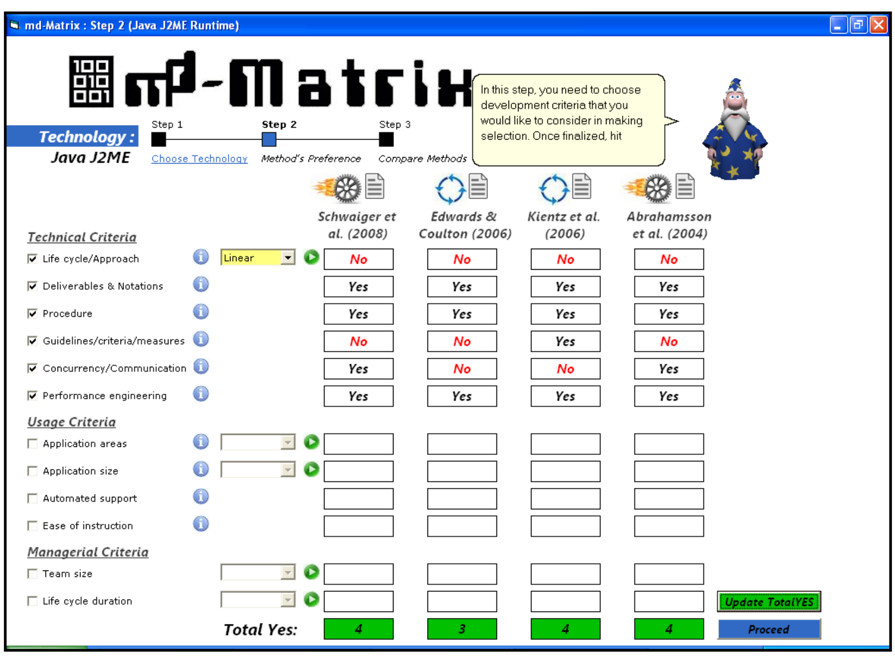


Figure 6.2: The 12 objective criteria used in non-compensatory (lexicographic) process

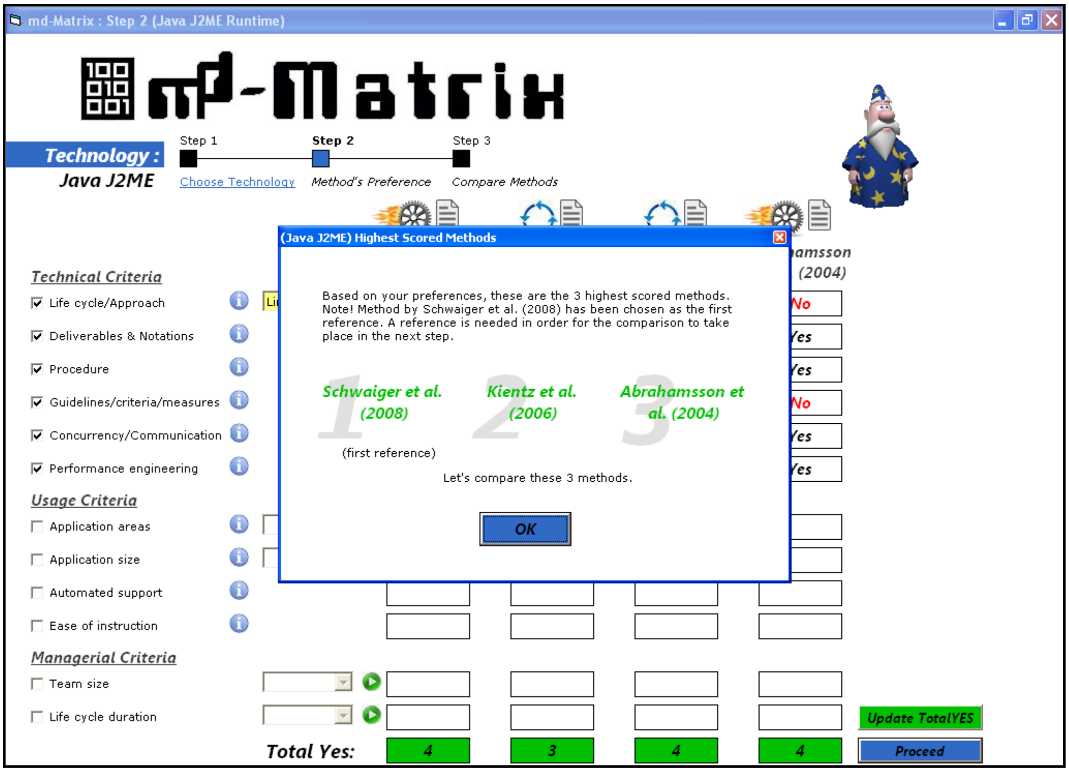


Figure 6.3: Result obtained in non-compensatory process

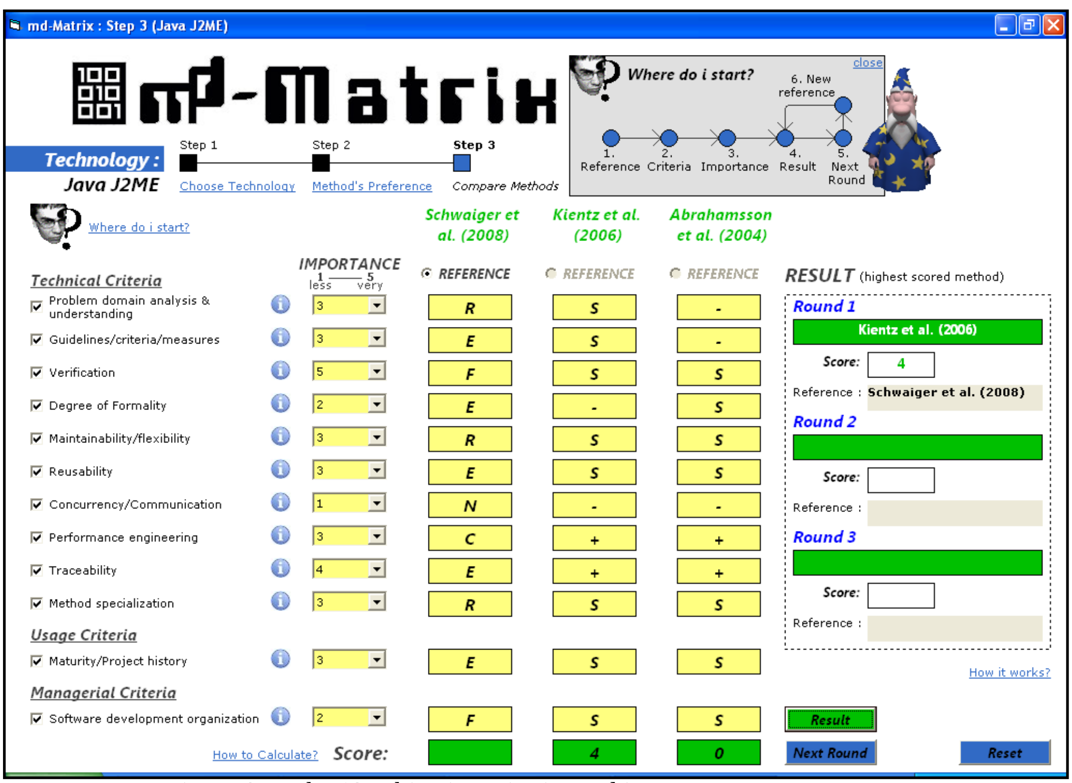


Figure 6.4: The 12 subjective criteria used in compensatory process

m^d-Matrix as a Learning Tool

Along providing solution to the selection of development methodology, md-Matrix also can be utilized as an educational tool either in academic or industry. Learning institutions can utilize it for teaching purposes to educate students on the need to have a well-structured process of developing mobile applications. As for the industry, this tool can be used as one of the materials for training of new interns and apprentice developers.

B. Case study 2: Choosing a Mobile Phone

Consumers are faced with purchase decisions mostly every time when a purchase is required. But not all decisions are treated the same. Some decisions are more complex than others and thus require more effort by the consumer. Other decisions are fairly frequent and require little effort.

Consumers will not simply go to a store or online catalog and spend their money in a rush. Purchasing takes place usually as a result of series of decision making steps. The implication of buying behavior shows the need for a reliable decision making tool to assist consumers in making a less-regretful and effective decision (Häubl & Trifts, 2000; Chris, 2008).

It is also important for the consumers to be able to decide on the purchasing item with confidence and ease. Thus, a comprehensive and undemanding decision aid is much needed in the process. Another important aspect is the use of decision aid in raising awareness about the consequences of actually choosing the item and purchases it. This could be obtained by organizing data with the purpose of presenting or displaying it to the decision maker (consumer) in a much clearer way than simply making a list of the alternatives. Within this perspective, the proposed PDADM is implemented in assisting consumers to make purchasing decision via the use of the prototype known as e^p-Matrix (as in electronic purchasing matrix).

Features and Screenshots of e^p-Matrix

The prototype (ep-Matrix) is developed to demonstrate an example of making a purchasing decision of a mobile phone. A well know brand of mobile phone is used for three reasons; the convenience of getting all the required data, the familiarity factor among consumers and for the purpose of evaluation later on. Table 6.2 summarizes the features of ep-Matrix that is developed for this case study:

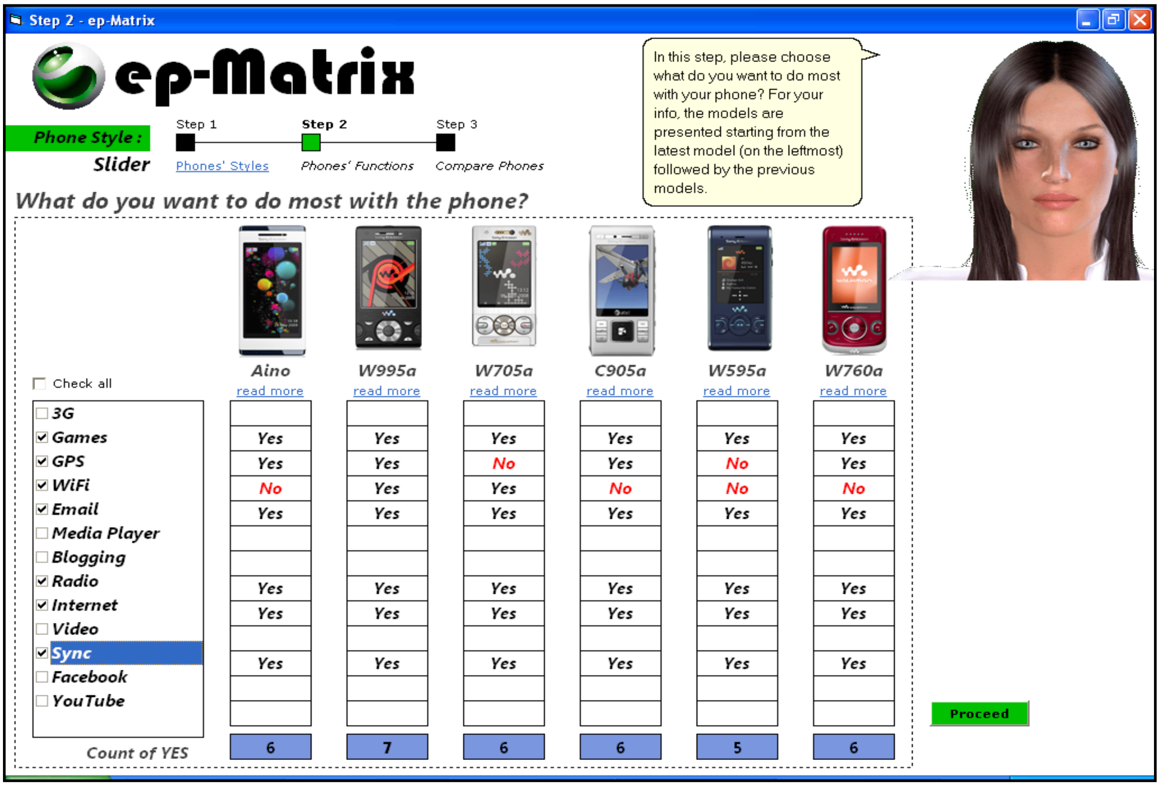
Table 6.2: Features of e^p-Matrix

ep-Matrix	
Alternatives filter	Mobile phone styles: Bar Slider* Touch Screen Folder/Flip QWERTY
Criteria	13 objective 9 subjective
Alternatives	Slider (6 models)
Feedback	Pop-up window, on-screen text, Interface agent

** enabled in this prototype*

The first step of e^p-Matrix enables user to filter the available phone models based on preferred style (Figure 6.5). As it proceeds with the second step (Figure 6.6), users will make their selection of objective criteria to further filter the options (phone models) following the non-compensatory strategy (lexicographic process). The three highest scored models (see Figure 6.7) which pass most of the selected criteria will be ranked accordingly and the one in the highest rank will be set as the first reference (datum). Next, the three identified models from previous step will be compared to each other following the compensatory strategy (modified Pugh's method) based on preferred subjective criteria (Figure 6.8). The steps can be iterated in maximum 3 cycles where in each round the reference will be changed until each model will be a reference once. The dominance model from the 3 rounds will be suggested as the best selection. The following are screenshots of e^p-Matrix:

Figure 6.5: Alternatives filtered categorically



	Aino	W995a	W705a	C905a	W595a	W760a
3G						
Games	Yes	Yes	Yes	Yes	Yes	Yes
GPS	Yes	Yes	No	Yes	No	Yes
WiFi	No	Yes	Yes	No	No	No
Email	Yes	Yes	Yes	Yes	Yes	Yes
Media Player						
Blogging						
Radio	Yes	Yes	Yes	Yes	Yes	Yes
Internet	Yes	Yes	Yes	Yes	Yes	Yes
Video						
Sync	Yes	Yes	Yes	Yes	Yes	Yes
Facebook						
YouTube						
Count of YES	6	7	6	6	5	6

Figure 6.6: The 13 objective criteria used in non-compensatory (lexicographic) process

Figure 6.7: Result obtained in non-compensatory process

Figure 6.8: The 9 subjective criteria used in compensatory process (modified Pugh's method)

VII. Helpfulness of PDADM Driven Prototypes

This study intends to investigate users' perception towards helpfulness of the PDADM driven prototypes in both case studies. In measuring helpfulness, quantitative data need to be gathered through an instrument. In addition to that, subjective input through interviews and observations might help enriching the collected data. To develop the instrument for measuring helpfulness, an elicitation work as summarized in Figure 7.1 was performed (Ariffin, 2009).

Figure 7.1: Summary of elicitation work

Figure 7.1 illustrates the processes involved in the instrument development; beginning with elicitation works to determine measuring items until the instrument is ready for pilot testing. The instrument was constructed based on the dimensions identified from elicitation work. Later, measuring items were added based on the reviewed literatures. Some modifications are made to the measuring items, in terms of rewording some items and repositioning some items into another dimension of the instrument. In measuring the helpfulness of the PDADM driven prototypes, this study is looking at four important dimensions; reliability, decision making effort, confidence, and decision process awareness. The instrument was then named as Q-HELP, which contains four dimensions: reliability, decision making effort, confidence, and decision process awareness

Table 7.1 illustrates the reliability of Q-HELP by each dimension. In the evaluation, respondents are required to rate the helpfulness level based on each dimensions using the seven point Likert scales; which are 1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = undecided, 5 = somewhat agree, 6 = agree and 7 = strongly agree. Respective measuring items can be seen in Table 7.2.

Table 7.1: Reliability of dimensions in Q-HELP

Dimensions	Cronbach Alpha value
Reliability	0.755
Decision making effort	0.689
Confidence	0.906
Decision process awareness	0.771

One hundred and seven respondents participated in the lab experiment; 63 of them were evaluated for the first case study where as 44 for the second case study. The experiment proceeded in two steps for each case study. In the first step, participants were required to accomplish the selection task aided by other tool or material. The main concern is to study the process that they went through before they can actually make a selection. In the second step, participants solved the same decision problem by making selection with the assistance of proposed PDADM driven prototypes in each case study.

Upon completion of both steps, participants were requested to answer 26 questions from all four dimensions of helpfulness in Q-HELP. The instrument recorded their perceptions and experiences of making a selection for the same decision problem in the experiment. Table 7.2 also depicts the mean responses for each item in Q-HELP answered by participants in respective case studies.

Table 7.2: Q-HELP items and mean responses by each item for each case study

Reliability	m^d-Matrix *n=63*	e^p-Matrix *n=44*
{*name of prototype*}* can be relied to function properly.	5.22	5.84
{*name of prototype*}* is suitable to my style of decision making.	5.02	5.43
{*name of prototype*}* is capable of helping me in making a choice.	5.25	5.80
{*name of prototype*}* provides the help that I need to make a selection.	5.33	5.75
{*name of prototype*}* provides the advice that I require to make my decision.	5.08	5.64
I would use {*name of prototype*}* if I were attempting to make a choice that is "good enough" but not necessarily the best.	4.95	5.82
{*name of prototype*}* is suitable even during limited time to make a decision.	5.03	5.82
Group Mean A	5.13	5.73
Decision making effort		
It was very time consuming to choose a {item} from the available options.	4.81	5.39
It was very difficult to choose a {item} from the available options.	4.43	5.27
{*name of prototype*}* allowed me to carefully consider the decision made.	5.35	5.84
The decision process in {*name of prototype*}* is logical to me.	5.30	6.14
The decision process in {*name of prototype*}* is simple to me.	5.19	5.91
I understand how decision process in {*name of prototype*}* works.	5.17	5.70
I found it very easy to interpret the decision justification provided by {*name of prototype*}*.	5.06	5.77
Group Mean B	5.04	5.72
Confidence		
I am satisfied with the recommended solution.	5.27	5.75
The recommended solution reflects my initial preferences.	5.16	5.61
I am confident that I am able to make selection with {*name of prototype*}*.	5.17	5.86
I am confident that I can justify the selection that I made with {*name of prototype*}*.	5.17	5.93
I feel that the problem in making selection is solved.	5.05	5.45
I am very pleased with my experience using {*name of prototype*}*.	5.48	5.77
Group Mean C	5.22	5.73
Decision process awareness		
{*name of prototype*}* makes me realize I cannot get everything from just one alternative.	5.44	5.93
{*name of prototype*}* is an aid for me in clarifying what I want.	5.27	5.84
{*name of prototype*}* shows my subconscious decision process.	5.11	5.73
{*name of prototype*}* helps me not to be easily influenced by others in making selection.	5.29	5.98
{*name of prototype*}* makes me more independent of others in making a selection.	5.22	6.00
I learned a lot about the problem using {*name of prototype*}*.	5.48	6.00
Group Mean D	5.30	5.91

**replaced with m^d-Matrix or e^p-Matrix based on respective case studies*

VIII. RESULTS

As mentioned earlier, the instrument used in evaluating the helpfulness of the PDADM driven prototypes is looking at four important dimensions; reliability, decision making effort, confidence, and decision process awareness. Table 7.2 presents means of responses to the items in measuring the helpfulness of the prototypes in both case studies.

Questions A1 to A7 are used to assess the user's perceptions on reliability of the prototypes. For case study 1, the group mean score of items in dimension A was 5.13, indicating moderately high perception on reliability. In case study 2, the group mean score of the same items was 5.73, indicating high level of reliability.

Question B1 to B7 are used to assess the user's perceptions on effort invested in the decision making process with the assistance of PDADM driven prototypes. For case study 1, the group mean score for items in dimension B was 5.04, signifying moderately high perception on decision making effort among respondents. As for case study 2, the group mean score of the same items was 5.72, indicating high perception on the decision making effort.

Question C1 to C6 are used to assess the confidence level of respondents in solution and procedure applied in the decision aids. In case study 1, the group mean score was 5.22, representing moderate confidence level among respondents. As for the second case study, the group mean score was 5.73, indicating higher confidence level among respondents after using the PDADM driven prototypes.

For the last dimension of the instrument, six items (items D1 to D6) have been asked to the respondents in order to measure their perception on decision process awareness. In case study 1, the group mean score of the last six items in Q-HELP was 5.30, representing moderate perception score on decision process awareness among respondents. For case study 2, the group mean score was 5.91, signifying high perception score on decision process awareness.

From the analysis above and as can be summarized in Figure 6.9 , generally the mean scores of each dimension fall under category moderately high or high, indicating that participants were incline to perceive the use of PDADM driven prototypes as helpful even in different personal decision situations. In both prototypes, participants rated highly on decision process awareness, this is followed by their perceived confidence and reliable in the decision aids.

Upon further analysis, participants responded highly on the items under reliability and confidence as depicted in Figure 6.10 and 6.11. Therefore, it can be concluded that both decision aids:

i. provide the help that participants needed to make a selection,
ii. can be relied to function properly
iii. are capable of helping participants in making a choice

Also, the participants were:

i. very pleased with their experience using the decision aids
ii. confident that they can justify the selection that have been made with the decision aids
iii. satisfied with the recommended solution
iv.

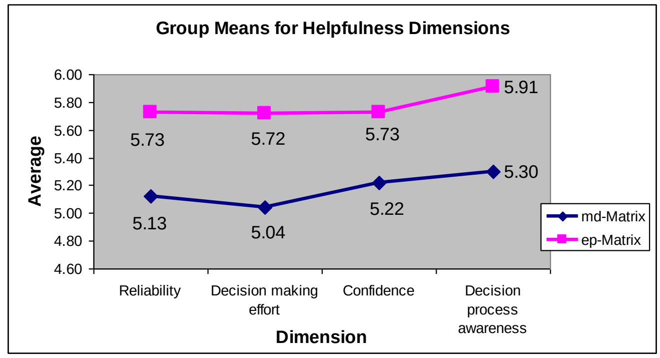


Figure 6.9: Group means for helpfulness dimensions

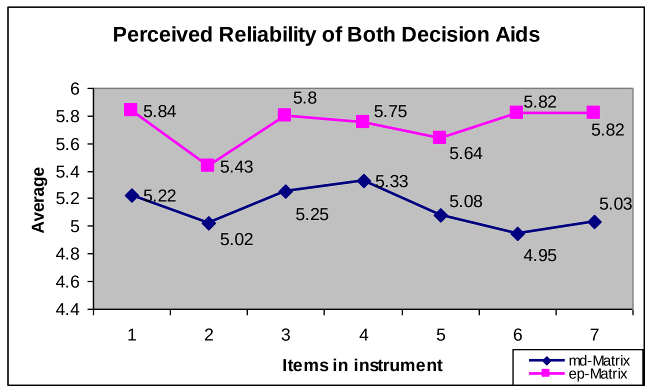


Figure 6.10: Perceived reliability of m^d-Matrix and e^p-Matrix

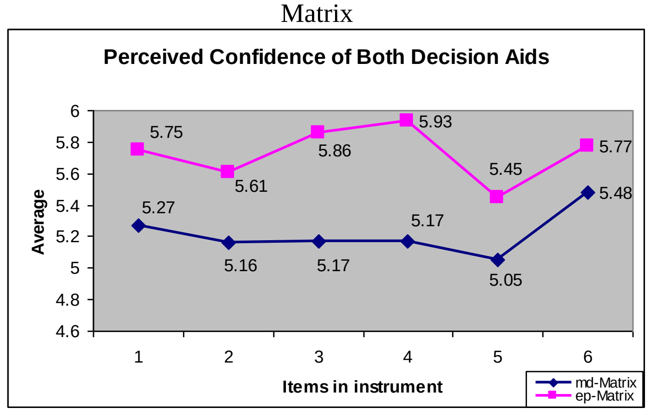


Figure 6.11: Perceived confidence in m^d-Matrix and e^p-Matrix

IX. CONCLUSION

Despite the existence of various computerized decision aids, decision maker perceptions of the ideal decision strategy and technique have not been subjected to systematic investigation. In doing so, this study seeks to contribute the following, along achieving the previously stated objectives:

i. In general, this study will contribute to decision making area as well as cross-disciplinary area which is related to the decision situation
ii. A proposed decision making model for personal decisions with emphasis on the non-expert use.

iii. Two prototypes which utilizing the proposed decision model in two different situations; purchasing decision and educational decision.
iv. Algorithms of the developed prototypes.
v. Instruments to measure users' perceived helpfulness of the prototypes.
vi. A comparative analysis of five decision strategies which provides research basis for related future studies.

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