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Decision-Making Model on DSLR Camera Choosing for 18 ~ 30 Years Old College Students

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Abstract--A 3-level Hierarchical Decision Model (HDM) [1] is established in this paper to help 18-30 year old college students make a decision of choosing a desirable digital single-lens reflex camera (DSLR) from 5 famous DSLR camera manufacturers. The HDM has been utilized in this paper, because it measures the relative contribution of each criterion to the final decision based on quantified judgments of the respondents. A group of experts, consists of 12 male and 9 female provided their quantified judgements with different weighted value in each element at each level of the decision hierarchy. By applying desirable functions, there was one most desirable camera picked from each manufacturer of the 5. Additionally, the research team also analyzed the judgments from experts for possible different judgements between gender groups, and showing no significant differences.

I. INTRODUCTION

The digital single-lens reflex camera (DSLR) is one of the most popular cameras on the market today, especially among young college students who have the hobby of photography. The major difference between a DSLR camera and normal digital camera is its reflex design. By using a single-lens, the viewfinder presents an image that will not perceptibly differ from what is captured by the camera's sensor. Comparing with other types of cameras, DSLR cameras have advantages on image quality, adaptability, speed, large ISO range, manual controls, depth of field, retaining value, etc.

In the camera market today, a large variety of DSLR cameras are developed to satisfy the different needs for certain customers. For instance, DSLR camera manufacturers divided the target customers into three groups, as the beginner level, semi-professional level and professional level, and so does they divided their production series for each level of customers. Since there are multiple options on different models from different brands that could be considered, it is difficult for a college student to making a final choice on picking a suitable DSLR camera. This paper presents the application of the Hierarchical Decision Model (HDM) on selecting the most desirable DSLR camera for college students aged 18-30. HDM has been chosen for this purpose because it allows the users to easily visualize how decision elements at each level of the decision hierarchy impact the final decision [2].

For this research, the group built up a 3-level HDM to serve the purpose. As an overview, from top to the bottom, there are five major criteria for the second level for experts to provide their quantified judgements with pairwise comparisons, which consist of budget, design, dimensions,

configuration and features; for the third level of the HDM, desirability functions were applied to find the relationship between disability value and performance levels in each major criterion [3].

Rather than come out only one camera for 18-30 years old college students, the research team considered the bias among different brand and offered different recommendations in each brand. In addition, this paper also checked the possible different opinions between male and female customers by analyzing the judgments from experts.

II. LITERATURE REVIEW ON DECISION MAKING AND MULTI-ATTRIBUTE DECISION MAKING METHODS

"Decision making is the study of identifying and choosing alternatives based on the values and preferences of the decision maker." [4] When people are making decisions on what action they would like to take under certain situation, they would need to pick up one alternative as their choice out of many choices they may have. The whole process from identification of the decision maker(s) and stakeholder(s) in the decision [5]; defining the questions; assessing all the possible alternatives and searching for the best fit to their goals, objectives, and the maximum values; until pick up the final choice, would be the general process of a decision making process. During the process, from different stakeholders or stakeholder groups, there may have different perspectives based on their own role and value proposition. One of the major task for decision maker to use decision making methods/tools, is to capturing the opinions from related stakeholders, reduce the disagreements from the different stakeholders or stakeholder groups, and provide the decision that could represent the general interests and opinions.

From a generally speaking, the decision making process would including the following steps [6]:

- Define the problem, including: "identify root causes, limiting assumptions, system and organizational boundaries and interfaces, and any stakeholder issues. [6]" In this step, the decision maker would need to get the agreement with the stakeholder that they are looking at the same problem that need to be solved, and they are sharing same visions.
- Determine requirements, which means the conditions that to accept the solution to the problem would need to be set in advance. From a mathematical perspective, the numerical constraints should be set in advance for the

further steps.

- Establish goals, which means the statement that is most desirable and must be met from the decision. From a mathematical perspective, it means the objective of the decision making model need to be set.
- Identify alternatives. When the root conditions changes, the possible alternatives would be changed as well, to become different choices for the potential final decision. Identifying alternatives would be helpful to give the decision maker a clear view of what might happen under different conditions, and the possible chain-effects on following steps.
- Define criteria, which could be helpful for developing the objective measurements of the goals to measure how well each alternative could match the goal [6].
- Select a decision making tool. Some research suggests that the tool could be as simple as possible, but also may need to use complex tools for complex situations.
- Evaluate alternatives against criteria. The function of decision making tools is to help with the evaluation of the alternatives, against criteria that had been set. The evaluation would be affected by the opinions and judgements addressed from stakeholders, or experts. After the evaluation, a subset of all the alternatives would become the validated solutions for the next step.
- Validate solutions against problem statement. Comparing with the problem statement, and pick up one of the alternatives as the final decision.

For most of the time, decision makers are facing the situation of multiple criteria with multiple different alternatives, which is defined as “Multi-attribute Decision Making” process [6]. Multi-attribute decision making techniques can partially or completely rank the alternatives, which means a single most preferred alternative can be identified or a short list of a limited number of alternatives can be selected for subsequent detailed appraisal [6].

There are two big families of multi-attribute decision making tools based on two different theoretical foundations: Multi-attribute Utility Theory (MAUT) and Outranking methods.

The family of MAUT methods consists of aggregating the different criteria into a function, which has to be maximized [6]. The major decision making methods in the family of MAUT methods are including: simple multi-attribute rating technique (SMART) [7]–[9], generalized means [10], and the analytic hierarchy process (AHP) [11].

The outranking methods, proposed by Roy [12] is based on the pairwise comparison between each of the two criteria of the alternatives, and pick up the highest-ranked one. By ranking all the alternatives, the subset of the alternatives could become as small as it could, or lead to the final

decision directly. The major decision making methods in the family of outranking methods are including: the ELECTRE methods [13] and the PROMETHEE methods [14]–[16].

Other than these two big families, some other general decision making tools are also popular to use in the decision making practices. Cost-benefit analysis (CBA) is a worldwide used technique in decision making, which evaluated the cost and benefits of the alternatives on monetary basis [6]. Also elementary methods are also be considered from the research as no computational support for decision makers [6]. Widely-used methods within the elementary methods family including: pros and cons analysis [5], maximin and maximax methods [17], conjunctive and disjunctive methods [17], and lexicographic method [17].

Hierarchical Decision Model (HDM) [1] is developed by adopt the pairwise comparison into hierarchical process. Previous research showing that combining pairwise comparison and hierarchical process could make the hierarchical decision making framework more powerful [6]. In this way, pairwise comparison between criteria could increase the accuracy on evaluating the criteria by scores. By using the hierarchical structure, the connections and impacts between criteria is showing as the correlated subjects, which is helpful for determine the disagreement level among the stakeholders or the experts. It also increased the capability of combining other analytical tools into the decision making process, such as sensitivity analysis [18], which would lead to the best preferred alternative for the general interests of the stakeholders.

In the following parts of the paper, an application case of HDM approach on decision making for pick up a Digital SLR camera for the college students from 18~30 years old will be shown.

III. RESEARCH DESIGN

The research design of in this project contains seven steps as the following:

Step 1: Literature Review. In this step, members read literature reviews about camera, HDM model [1]–[3] and also found new information from professional photographer website [19],[20] together with information from camera product website [21]–[24]. This gave the team enough information to identify the major criteria for the HDM, and to build a possible product list of DSLR cameras for the desirability functions.

Step 2: Model Development. By using the online HDM application that developed by Engineering and Technology Management department from Portland State University, the group was being able to build up a 3-level HDM as showing in Figure 1:

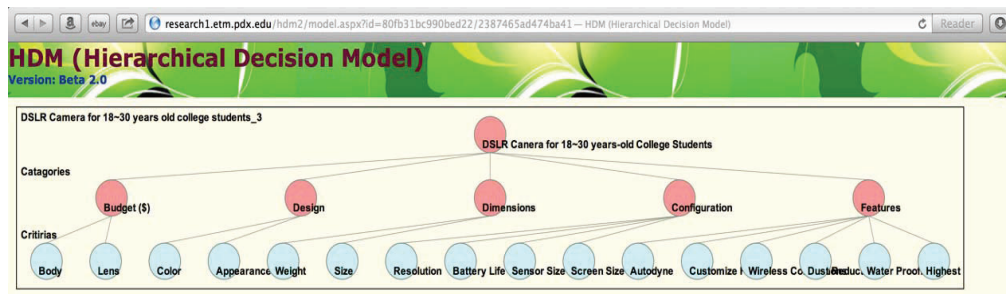


Figure 1 HDM model of DSLR Camera for 18-30 year-old college students (source: <http://research1.etm.pdx.edu/hdm2/>)

There are five criteria which are *Budget* (the amount of money that students are willing to pay for DSLR camera include of budget for Body and Len), *Design* (The characteristics of DSLR camera produced from factory to show the look of DSLR camera include of Color and Appearances), *Dimensions* (A measurable extent of some kind, can be divided into Weight and Size), *Configuration* (An arrangement of elements in a particular form, figure, or combination, which include of Resolution, Battery life, Sensor size and Screen size), and *Features* (A distinctive attribute which consisted of Autodyne, Customize filter, Wireless connection, Dust reduction, Water proofing and

High shutter speed). This paper did not use *Brand of DSLR camera* as criteria to reduce the possibility of *Brand Bias* from different person's flavors on their preferred brands.

Step 3: Judgment Quantification. The model was distributed to college students, aging 18 – 30, who had experiences with buying DSLR camera, with a detailed instruction on how to use the online application of HDM and the explanations of each criteria. They became the experts for responding on the model. By giving weights of relative importance for each of the criteria, the pairwise comparisons between each major criteria and sub criteria was shown as they responded as showing in Figure 2.

Figure 2: An example of pairwise comparison for expert judgment

DSLR Camera for 18-30 years-old College Students	Body	Lens	Color	Appearance	Weight	Size	Resolution	Battery Life	Sensor Size	Screen Size	Autodyne	Customize Filter	Wireless Connections	Dust Reduction	Water Proofing	Highest Shutter Speed	Inconsistency
Anna-Lena Lertz	0.14	0.14	0.04	0.06	0.12	0.05	0.05	0.06	0.03	0.05	0.03	0.04	0.04	0.05	0.07	0.03	0
Baiyu Liu	0.11	0.22	0.02	0.06	0.04	0.1	0.07	0.03	0.08	0.01	0.01	0.02	0.04	0.06	0.07	0.03	0.02
Hao Yang	0.04	0.15	0.05	0.16	0.11	0.02	0.01	0.04	0.03	0.04	0.07	0.03	0.07	0.06	0.05	0.07	0.02
jiabing zhang	0.09	0.12	0.04	0.07	0.07	0.14	0.06	0.05	0.06	0.04	0.03	0.03	0.04	0.04	0.05	0.07	0.01
lan jiang	0.21	0.1	0.24	0.06	0.15	0.03	0.02	0.02	0.03	0.01	0.03	0.05	0.01	0.02	0.02	0.01	0.03
Larry Pham	0.08	0.04	0.08	0.18	0.11	0.11	0.04	0.03	0.08	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0
mengyuan ren	0.27	0.15	0.21	0.06	0.14	0.02	0.03	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0	0.02
monticha khammuang	0.12	0.18	0.04	0.07	0.07	0.04	0.06	0.07	0.05	0.07	0.08	0.04	0.03	0.03	0.03	0.03	0.01
nam dinh	0.28	0.12	0.01	0.13	0.06	0.03	0.06	0.08	0.03	0.01	0.05	0.04	0	0.03	0.01	0.06	0.01
Nattapong Khanom	0.1	0.04	0.01	0.1	0.11	0.03	0.16	0.01	0.11	0.02	0.03	0.04	0.01	0.1	0.05	0.07	0.08
Noppadon Vannaprapa	0.14	0.21	0.04	0.07	0.07	0.07	0.03	0.05	0.09	0.04	0.02	0.04	0.03	0.04	0.04	0.04	0.03
paweena kongsansatean	0.15	0.09	0.13	0.04	0.08	0.06	0.07	0.09	0.04	0.05	0.02	0.03	0.04	0.04	0.04	0.03	0.01
pei zhang	0.06	0.31	0.02	0.05	0.09	0.02	0.06	0.03	0.14	0.01	0.01	0.02	0.03	0.06	0.05	0.03	0.02
sanut choothian	0.12	0.23	0.04	0.03	0.08	0.01	0.06	0.02	0.07	0.02	0	0.01	0.02	0.08	0.09	0.1	0.02
Sasha Nussbaum	0.02	0.08	0.04	0.22	0.1	0.04	0.05	0.06	0.05	0.02	0.03	0.04	0.04	0.04	0.07	0.1	0.02
standley limarta	0.04	0.18	0.04	0.07	0.07	0.07	0.06	0.02	0.16	0.01	0.05	0.03	0.04	0.05	0.04	0.07	0.02
Sudarat Poocharat	0.06	0.17	0.1	0.25	0.02	0.11	0.07	0.05	0.03	0.03	0.02	0.02	0.04	0.01	0.01	0.01	0.01
vichai saelor	0.05	0.14	0.01	0.09	0.01	0.12	0.09	0.13	0.04	0.1	0.02	0.03	0.04	0.04	0.05	0.05	0.02
Weixiao Huang	0.04	0.06	0.06	0.15	0.14	0.14	0.08	0.07	0.1	0.04	0.01	0.03	0.02	0.02	0.02	0.03	0
Worant Muangsi	0.06	0.06	0.02	0.09	0.03	0.08	0.16	0.1	0.05	0.02	0.01	0.04	0.01	0.04	0.07	0.15	0.04
Mean	0.11	0.14	0.06	0.1	0.08	0.06	0.06	0.05	0.06	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.05
Minimum	0.02	0.04	0.01	0.03	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Maximum	0.28	0.31	0.24	0.25	0.15	0.14	0.16	0.13	0.16	0.1	0.08	0.05	0.07	0.1	0.09	0.15	
Std. Deviation	0.07	0.07	0.06	0.06	0.04	0.04	0.04	0.03	0.04	0.02	0.02	0.01	0.02	0.02	0.02	0.04	
Disagreement																	0.04

The statistical F-test for evaluating the null hypothesis (H0: $\rho = 0$) is obtained by dividing between-subjects variability with residual variability:

Source of Variation	Sum of Square	Deg. of freedom	Mean Square	F-test value
Between Subjects:	0.30	15	.02	10.41
Between Conditions:	0.00	19	0.000	
Residual:	0.56	285	0.002	
Total:	0.86	319		
Critical F-value with degrees of freedom 15 & 285 at 0.01 level:				2.1
Critical F-value with degrees of freedom 15 & 285 at 0.025 level:				1.88
Critical F-value with degrees of freedom 15 & 285 at 0.05 level:				1.7
Critical F-value with degrees of freedom 15 & 285 at 0.1 level:				1.51

Figure 3: The result from calculations of each expert and the whole group

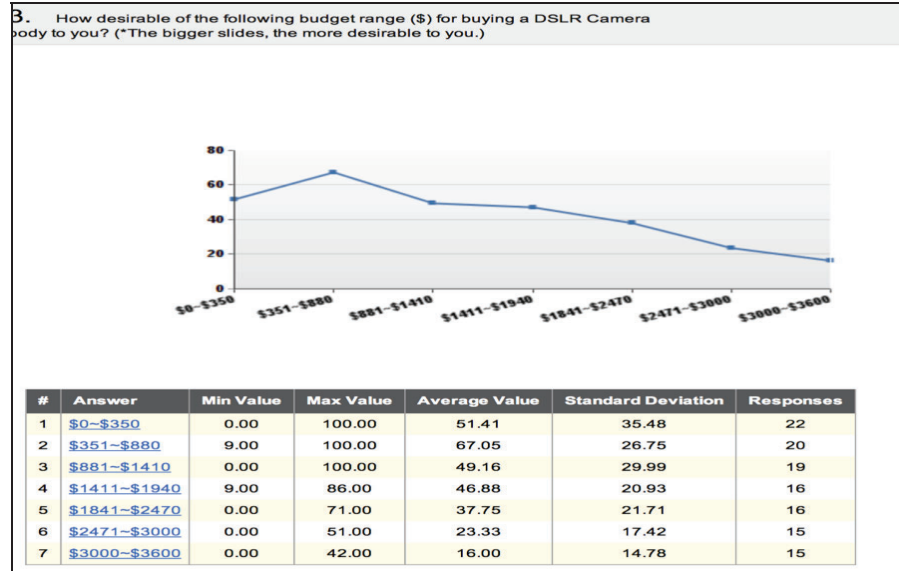


Figure 4: An example of desirability curve and result from expert judgment

With the calculations done by the application, regarding to the responds from experts, the relative values, inconsistency of their responds, and disagreement of each expert's evaluation had been shown as in the Figure 3.

Step 4: Desirability Function. After setting up the value ranges or options for each sub-criteria on the 3rd level of HDM in details and designed as an additional questionnaire [25] for the experts, the research group was been able to apply desirability functions in order to identify the most desirable camera models from each manufacturer from the experts' choice on their most desirable options.

By analyzing the responses, the desirability curves would be shown as Figure 4.

Step 5: Analyzing the results basis on both the dimensions from HDM result and desirability function results.

Step 6: Getting the summary of results.

Step 7: Showing the most desirable DSLR camera models basis on exited products of the 5 most active DSLR camera brands (Sony, Nikon, Canon, Olympus and Pentax), by using the product list built before from the literature review, associating with the HDM and desirability function results. The camera model which got the highest score was the most desirable of DSLR camera.

IV. HDM RESULTS AND ANALYSIS

A. Building up the HDM Model:

The model building began with a brain storming for the possible elements that may needed for the model, associated with the resources from the professional photographer websites, the official websites of big camera brands, and marketing researches. The goal was to design an empirical model using the most important criteria but not exhaustive to the point of inefficiency. The research team also considered the suggestions from our experts who took the pairwise judgments for the HDM model on how to picking up the most

important factors to put in the model and simplifying it, and the final model has been shown in Figure 1 above.

This model has two levels from the top to the bottom. Level 1 has 5 categories of the factors, and Level 2 has 16 criteria:

- Budget: how much would you like to pay for your camera? It has two criteria's for Level 2 as body and lens
- Design: how do you consider your camera would be looked at? The DSLR camera users may not only consider about getting high-quality photographs, but also consider about how they look like when they are carrying their cameras. The users themselves would also be attracted by some of the great camera appearances when they first saw them. There would possibly showing different judgments between male and female user groups. It also has 2 criteria's for Level 2 – appearances and colors.
- Dimensions: how big and how heavy would you like for your camera? This category is in the purpose of getting the adjustments on how the experts like for the measurements of the cameras on size and weight, which are also the 2 criteria's for this category. According to the experts' suggestions, they would like to see some of the changes on the dimensions of the cameras in the future if possible. They would like to have the size that would be suitable for their two-hand holdings and not too heavy to be carried around. There might also be some of the different judgments between male and female groups.
- Configuration: what basic hardware qualities you would like for your camera? This category has 4 criteria's as the basic hardware that the DSLR camera users concerns about the most:
 - Resolution: The resolution refers to the image sensor resolution for the camera, which describes the smallest change a sensor can detect in the quantity that is measuring.

- Battery Life: It would be really struggle for a DSLR camera user who would have to change batteries when a great view is in front of the lens.
- Sensor Size: Another important thing to consider about the features of the image sensor is related to the size of the sensor.
- Screen Size: This is the measurement of the monitor screen size on the backboard of the camera. The popular screen size range in the market now is from 0.9~3.5inch.
- Features: Rather than the basic features of the cameras, the DSLR users now might like to have some more advantage features which beyond the basic features. These features would also be valuable for the college users to define which model of camera they would like to pick up, and also for the manufacturers to improve the features of the camera in the futures. It has 6 criteria:
 - Autodyne: This feature is also being called as the “selfi” feature, which means you could take picture of yourself by yourself with your camera. For a DSLR camera, this feature may relate to the design of the rotational screen.
 - Customize Filters: Some of the experts involved said that if the camera could have the feature that they could use customize filters to add with special color effects or do some simple editing works, they would be really comfortable with this feature.
 - Wireless Connections: Some of the DSLR cameras now have the feature of wireless connections as GPS, Wi-Fi, and Bluetooth, which could connect your camera to other devices as Wi-Fi printers, or smartphones to print or see the pictures in multiple devices. This might provide the conveniences to the users, but another concern is about the private information safety issues.
 - Dust Reducing: This is one of the features which could support your camera to work in the extreme conditions, and protect your camera sensors would not be hurt by the dusts.
 - Water Proofing: This is another feature that could support your camera to work in the extreme conditions.
 - Highest Shutter Speed: The high-speed shutter is one of the most important feature that DSLR camera could do but not for the regular digital cameras. One of the features to measure this performance is the highest shutter speed of the camera.

Based on the responds from the exports, the analysis would show which of the criteria would the college users considered the most, and if there would be some differences between the male group and female group.

B. Picking up the experts.

After building up the HDM model, the next step would be picking up the experts who would like to give out their

judgments and opinions on these factors. Since the target group of this project is the college students from 18~30 years old, so our experts group was also picked up from this group of college students around PSU campus. The other important thing is that all of our experts are having the experiences on using DSLR cameras, which could be able to understand all of the factors in the model about the camera. Basic on their own experience, they would be able to give out reliable judgments with a consistency status.

For this project, we have got the experts group with 21 in total. In this group, we have got 12 male experts and 9 female experts. By dividing up the judgment into male group and female group, the research group would be able to find possible differences between the two expert groups.

The major technics would be applied by the research team to find out about the disagreements or different opinions are:

- Disagreement Value. If the disagreement value is under 1.0, it would be considered as there was no disagreement within the certain group.
- Average HDM Weight. By comparing the average HDM weights, the research team would be able to find out if there are differences between male group and female group.

C. Analysis and Results:

1. Level-1, Male Group:

For the male experts group's judgments for Level 1, the disagreement value of the male experts' group is equal to 0.07, which is less than 1.0, meaning there is no disagreements among the male experts' group for the judgments on the Level 1 categories of the factors. From the mean value of the HDM weights, the most important thing that male experts are considering about is “Features” (0.26) of the camera, which would related to the user experience, and the concerning on a better performance of the camera. The following factors for male's group to be considered are: “Budget” (0.25) and “Configuration” (0.23). They would also like to by the cameras they would afford, and getting as good as the basic features would be in the certain price ranges. For the “Design” (0.13) and “Dimensions” (0.14), the male experts' group did not give so much weights on, which means they may not concern these categories as much as they would pay attentions on the other factors.

2. Level 1, Female Group:

According to the data for the female experts' group, the calculations were showing the disagreement value within the female experts' group was equal to 0.04, less than 1.0, meaning there is no disagreement among the female experts' group. From the mean value of the HDM weight, the most important thing for the female experts to be considered about is the “Budget” (0.25), the second thing they were considering about is the “Design” (0.22). So they would like to pick up the camera that they could afford to and has the looking as well as possible within the current price ranges.

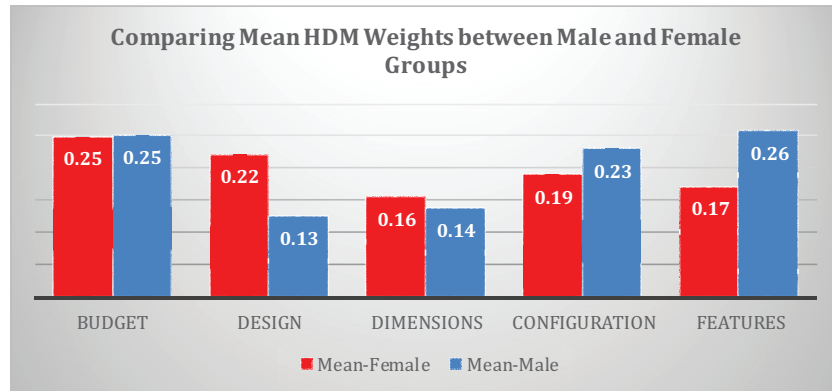


Figure 5: Comparing Mean HDM Weights between Male and Female Groups

3. Level 1, Between Male and Female on Mean HDM Weights:

According to the data and calculations, the comparing results between male and female groups on mean HDM weight values could be shown as the chart in figure 5.

From the above figure, both of the male and female groups had put 0.25 weight for the “Budget” as the important thing to be considered. For other factors, female group had given “Design” as much weight as 0.22, which is more than male experts’ group as 0.13; for male group, they had given the “Features” 0.26 for the weights value as their most important factor to be considered, while female group just gave 0.17 as the value. And also the male group gave the “Configuration” as much as 0.23 for another important factor to be considered.

It is surprisingly to see that both of the groups did not give much weights on “Dimensions”, which seems like, for the college student group, they would not worry about how big it is, or heavy it is. They would like to take their cameras with great performances.

4. Level 1, the Whole Group:

After comparing with the male and female experts’ groups above, it would be necessary to see how it goes when we come up with whole group.

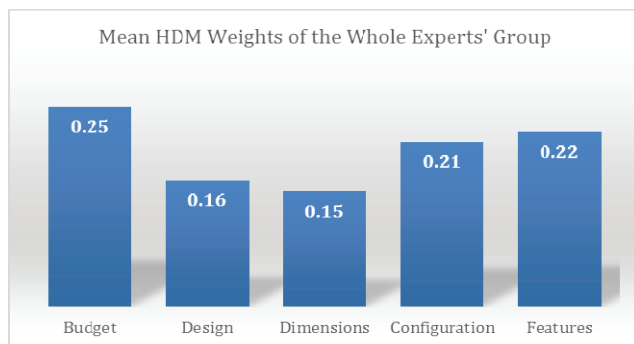


Figure 6: Mean HDM Weights of the Whole Experts’ Group

From the calculation, the disagreement value of the whole group was 0.08, which means that there was no disagreement

among all the experts together. For the mean values of the HDM weights, the research group was able to find out the weights for different factors that given by all of the experts from the research as the Figure 6.

From the figure above, the “Budget” had gain the most weight from the experts’ judgment with the weight of 0.25. This is a very reasonable result because the budgets of camera for a college student should always be considered as the first thing to be considered, since the college students may not have that much money to be spent on cameras. The following important factors to be considered about are “Features” (0.22) and “Configuration” (0.21) which are related to the camera’s performances. This is showing out the sign that the college students group would consider about the performances more than the appearances and dimensions of their cameras. On the other hand, with a better Configuration and Features, they would be able to apply their skills better and have a better user experiences. They would like to enjoy the controlling with the cameras and doing creative works.

5. Level 2, Male Group:

In the second level of the HDM model, by the responses from experts on detailed criteria, some significant signs were also showing from the calculations.

For the male experts’ group, their disagreement value is equal to 0.04, which is less than 1.0. This means there is no disagreement among the male experts’ group on the judgments for the detailed criteria. And also from the calculation results, for the male experts’ group, they gave the most HDM weights on the budgets for Lens (0.15) and Camera Body (0.10), especially for the lens. As most of the male users, they would spend time on how to pick up a lens set to meet their requirements for certain conditions, and match the features of their camera bodies; and they would like to spend money on increasing their lens collections.

The following criteria, very surprisingly from the male experts’ group, is the “Appearance” (0.09) of the camera. This showing that even for the male group, they would still consider about the appearance of their cameras. They would like to use the cameras which could help them improving their own appearances at the same time. And sometimes even

for the male users, they would be attracted by the well-designed cameras and willing to pay their money on. It could also be a good way to get male users from the market. The “Sensor Size” (0.08) of the camera was another important factor to affect the male group’s choices, which could provide a good performances on the image qualities of the cameras.

6. Level 2, Female Group:

From the calculation for the female expert group, the disagreement value of female experts’ group is 0.02, which is less than 1.0. There is no disagreement among the female experts’ group. And they gave the most weights to the budgets on camera body (0.13) and lens (0.13). It shows out that for the female experts, they may take the camera body and lens as the same important thing to be considered about. The following important factors among the female experts’ group are: “Weight” (0.11), “Color” (0.10), and “Appearance” (0.09). From these data, we could see that, for the detailed criteria, the female group would give more weights to the weight, color and appearance than the male

experts’ group. When the female users come into the market, they may more willing to pay for the pretty-designed cameras than the male group.

7. Level 2, Comparing the Mean HDM Weights between Male and Female Groups:

By comparing the different mean HDM Weight values, we would find out what differences between the male group and female groups. The plot is as in the Figure 7.

From the above plot, it shows clear that, the male group would like to spend more money on lens than the female group, and they would focus more on the “Resolution”, “Dust Reduction”, “Highest Shutter Speed” and “Water Proofing” than female group. It shows out that the male group would focus more on the features which are related to the camera features themselves. From the female group side, they would like to focus more on “Color” and “Weight” than the male group, which shows that the female college students would consider more on how convenient it could be for them to use and carry around.

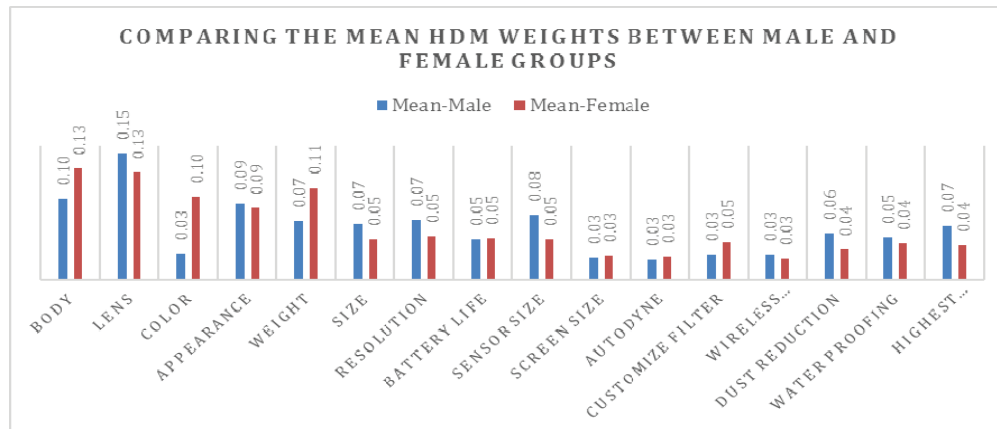


Figure 7: Comparing the Mean HDM Weights between Male and Female Groups

TABLE 1: CALCULATION CHART FOR THE WHOLE GROUP

DSLR Camera for 18-30 years-old College Students	Body	Lens	Color	Appearance	Weight	Size	Resolution	Battery Life	Sensor Size	Screen Size	Autodyne	Customize Filter	Wireless Connections	Dust Reduction	Water Proofing	Highest Shutter Speed	Inconsistency
Anna-Lena Lentz	0.14	0.14	0.04	0.06	0.12	0.05	0.05	0.06	0.03	0.05	0.03	0.04	0.04	0.05	0.07	0.03	0
Baiyu Liu	0.11	0.22	0.02	0.06	0.04	0.1	0.07	0.03	0.08	0.01	0.01	0.02	0.04	0.06	0.07	0.03	0.02
Hao Yang	0.04	0.15	0.05	0.16	0.11	0.02	0.01	0.04	0.03	0.04	0.07	0.03	0.07	0.06	0.05	0.07	0.02
jiabing zhang	0.09	0.12	0.04	0.07	0.07	0.14	0.06	0.05	0.06	0.04	0.03	0.03	0.04	0.04	0.05	0.07	0.01
lan jiang	0.21	0.1	0.24	0.06	0.15	0.03	0.02	0.02	0.03	0.01	0.03	0.05	0.01	0.02	0.02	0.01	0.03
Larry Pham	0.08	0.04	0.08	0.18	0.11	0.11	0.04	0.03	0.08	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0
mengyuan ren	0.27	0.15	0.21	0.06	0.14	0.02	0.03	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0	0.02
monticha khammuang	0.12	0.18	0.04	0.07	0.07	0.04	0.06	0.07	0.05	0.07	0.08	0.04	0.03	0.03	0.03	0.03	0.01
nam dinh	0.28	0.12	0.01	0.13	0.06	0.03	0.06	0.08	0.03	0.01	0.05	0.04	0	0.03	0.01	0.06	0.01
Nattapong Khanom	0.1	0.04	0.01	0.1	0.11	0.03	0.16	0.01	0.11	0.02	0.03	0.04	0.01	0.1	0.05	0.07	0.08
Noppadon Vannaprapa	0.14	0.21	0.04	0.07	0.07	0.07	0.03	0.05	0.09	0.04	0.02	0.04	0.03	0.04	0.04	0.04	0.03
pawena kongsansatean	0.15	0.09	0.13	0.04	0.08	0.06	0.07	0.09	0.04	0.05	0.02	0.03	0.04	0.04	0.04	0.03	0.01
pei zhang	0.06	0.31	0.02	0.05	0.09	0.02	0.06	0.03	0.14	0.01	0.01	0.02	0.03	0.06	0.05	0.03	0.02
sarut choothian	0.12	0.23	0.04	0.03	0.08	0.01	0.06	0.02	0.07	0.02	0	0.01	0.02	0.08	0.09	0.1	0.02
Sasha Nussbaum	0.02	0.08	0.04	0.22	0.1	0.04	0.05	0.06	0.05	0.02	0.03	0.04	0.04	0.04	0.07	0.1	0.02
standley limarta	0.04	0.18	0.04	0.07	0.07	0.07	0.06	0.02	0.16	0.01	0.05	0.03	0.04	0.05	0.04	0.07	0.02
Sudarat Poocharat	0.06	0.17	0.1	0.25	0.02	0.11	0.07	0.05	0.03	0.03	0.02	0.02	0.04	0.01	0.01	0.01	0.01
vichai saelor	0.05	0.14	0.01	0.09	0.01	0.12	0.09	0.13	0.04	0.1	0.02	0.03	0.04	0.04	0.05	0.05	0.02
Weixiao Huang	0.04	0.06	0.06	0.15	0.14	0.14	0.08	0.07	0.1	0.04	0.01	0.03	0.02	0.02	0.02	0.03	0
Woranut Muangsini	0.06	0.06	0.02	0.09	0.03	0.08	0.16	0.1	0.05	0.02	0.01	0.04	0.01	0.04	0.07	0.15	0.04
Mean	0.11	0.14	0.06	0.1	0.08	0.06	0.06	0.05	0.06	0.03	0.03	0.03	0.03	0.04	0.04	0.05	
Minimum	0.02	0.04	0.01	0.03	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
Maximum	0.28	0.31	0.24	0.25	0.15	0.14	0.16	0.13	0.16	0.1	0.08	0.05	0.07	0.1	0.09	0.15	
Std. Deviation	0.07	0.07	0.06	0.06	0.04	0.04	0.04	0.03	0.04	0.02	0.02	0.01	0.02	0.02	0.02	0.04	
Disagreement																	0.04

TABLE 2: F-TEST CALCULATION

The statistical F-test for evaluating the null hypothesis ($H_0: \mu_1 = \mu_2$) is obtained by dividing between-subjects variability with residual variability:

Source of Variation	Sum of Square	Deg. of freedom	Mean Square	F-test value
Between Subjects:	0.30	15	.02	10.41
Between Conditions:	0.00	19	0.000	
Residual:	0.56	285	0.002	
Total:	0.86	319		
Critical F-value with degrees of freedom 15 & 285 at 0.01 level:				2.1
Critical F-value with degrees of freedom 15 & 285 at 0.025 level:				1.88
Critical F-value with degrees of freedom 15 & 285 at 0.05 level:				1.7
Critical F-value with degrees of freedom 15 & 285 at 0.1 level:				1.51

8. Level 2, the Whole Group:

By using the HDM software, the research group also calculated the disagreement value of the whole experts' group, and providing an F-test to test if there is any disagreement among the whole group as showing in Table 1.

From the calculation above, the disagreement value of the whole group is 0.04, which is less than 1.0. Although there was some detailed differences between the male and female groups, there is no disagreement among the whole group. To prove the point, we could also look into the F-test value in Table 2.

From the chart above, the F-test value of the 0.05 level is 1.7; while the F-test value between subjects is 10.41. The F-test value of the whole group between subjects is much higher than the 0.05 level value, which means that there is no disagreement among the whole group when they consider to pick up their DSLR cameras and making decisions.

When looking into the mean HDM Weights, it could come up with important factors when they consider about the DSLR cameras as the following:

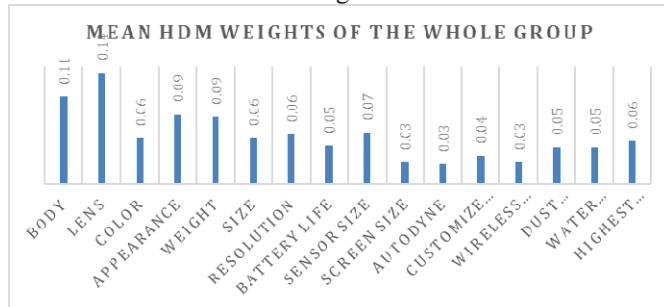


Figure 8: Mean HDM Weights of the Whole Group

From the plot of the whole group above, both of male and female groups were agreed with the most important factor to be considered would be the budget on cameras, especially for Lens (0.14) and Camera Body (0.11). Other important factors are: Appearance (0.09), Weight (0.09), Sensor Size (0.07) and the Highest Shutter Speed (0.06).

For the college student group, they would consider about the budgets as the first important factor. For other factors, the college students group would like to pay more attention on the appearance and weight of the camera which would show the capabilities for them to carry the cameras around easily and nicely with a comfortable weight and nice design.

V. DESIRABILITY RESULTS AND ANALYSIS

A. Desirability Questionnaire Design

Based on the DSLR HDM structure developed, "Budget of Camera Body" together with other 9 sub-criteria (factors) are selected for desirability value analysis (as depicted in Figure 4). For each factor, several category options are provided for experts to decide the level of desirability. By utilizing "Qualtrics" platform [11], the design of the desirability questionnaire can be conducted and responses from experts can be analyzed.

B. Desirability function equation

For purpose of calculating desirability score, the Technology Value [TV_n] approach developed by Dr. Gerdri and Dr. Kocaoglu are proposed to be used for analysis [1] [4].

$$TV_n = \sum_{k=1}^K \sum_{j=1}^{J_k} W_k * f_{j,k} * V(e_{n,j,k})$$

Where

TV_n : Technology value of technology (n) determined according to a company's objective

W_k : Relative priority of criterion (k) with respect to the company objective

$f_{j,k}$: Relative importance of factor (j_k) with respect to criterion (k)

$e_{n,j,k}$: Performance and physical characteristics of technology (n) along with factor (j_k) for criterion (k)

$V(e_{n,j,k})$: Desirability value of the performance and physical characteristics of technology (n) along factor (j_k) for criterion (k).

C. Desirability Results and Analysis

The desirability function results for each sub criteria (factor), the analysis are described in the following sections.

1. Budget of Camera Body and Lens

As it is shown in Figure 9 below, there is a peak point in \$351~\$880 category representing the most desirable camera body price range, whereas the other relatively higher price receive less desirability percentage. For the camera lens, \$0~\$500 and \$500~\$1000 categories are the most desirable.

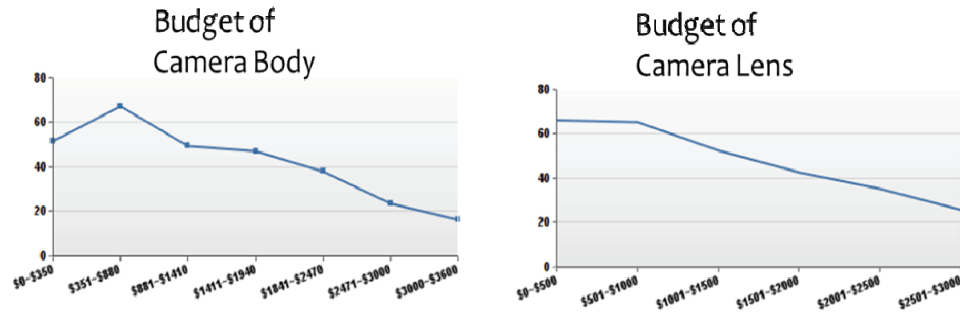


Figure 9: Desirability for Budget consideration on Camera Body and Lens

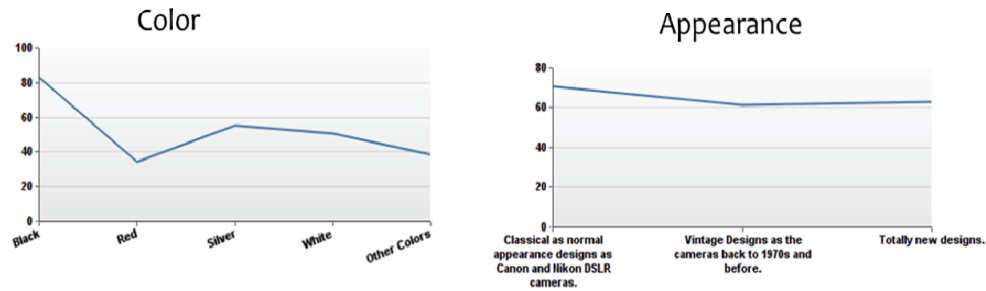


Figure 10: Desirability for Color and Appearance

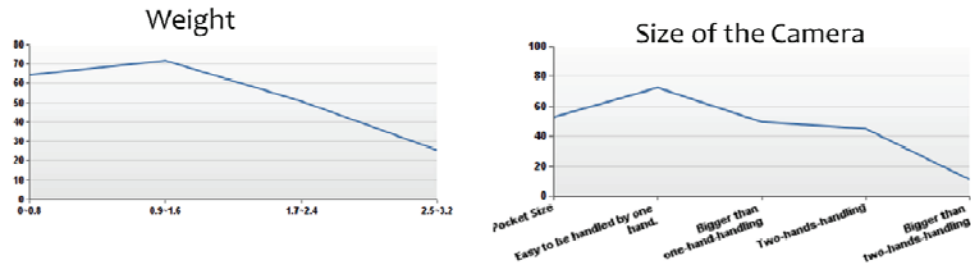


Figure 11: Desirability of Weight and Size of the Camera

2. Color and Appearance

In terms of camera color, black seems to be the most desirable choice, while red was the least desirable choice. For camera appearance, desirability results show that there exist various options selected without significantly different level of desirability. These may imply that there is no particular color or appearance design preferred by the college student group. The result is showing as the Figure 10.

3. Weight and Size of the Camera

The most desirable weight and size of the camera are

shown in “0.9~1.6” lb and “Easy to be Handled by One Hand” category respectively. Convenience of carrying and handling tend to be more preferential as shown in Figure 11.

4. Resolution and Sensor Size

The resolution level and sensor are considered directly relevant to the quality of the photo. The desirability curve shows that the higher resolution level and bigger sensor size are more desirable choices. These results also highlight the attractiveness of DSLR and justify the differentiation from ordinary digital cameras as shown in Figure 12.

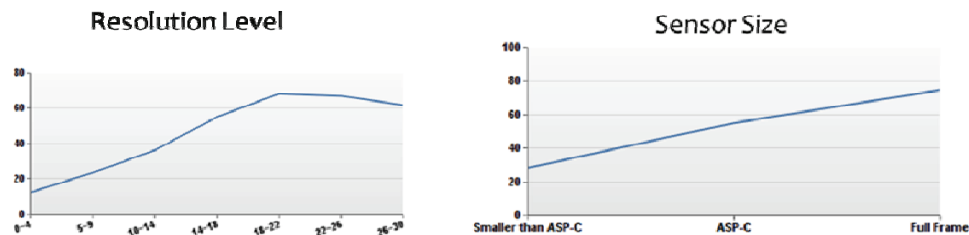


Figure 12: Desirability for Resolution Level and Sensor Size

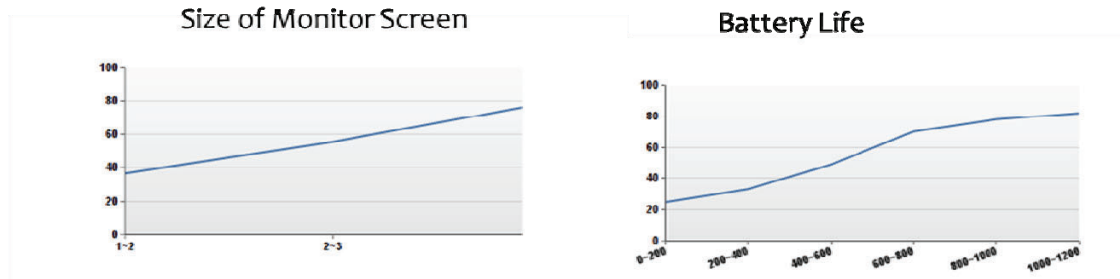


Figure 13: Desirability of Screen Size and Battery Life

5. Size of Monitor Screen and Battery Life

The result shows that bigger screen size and longer battery life are more desirable in comparison to other choices. These may imply that camera features related to ease of previewing and longer operating time are considered critical to the college student groups as shown in Figure 13.

D. Female and Male Sub group Results and Analysis

Based on the desirability results obtained from female and male sub group, there seems to exist similar curve patterns without major differentiation. However, for the results of “Resolution Level” and “Sensor Size” (as shown in Figure 14), the male sub group tend to have higher desirability requirements. It is shown that peak point of Resolution Level is 22~26 mega pixel (with mean value of 74.73%) for male and 18~22 mega pixel (with mean value of 69.25%) for female. For sensor size, male’s desirability for Full Frame is 86.23%, whereas female has 55.13% for this category. These results may be recognized as corresponding to the comparative results found in HDM analysis, where male tend to put relatively important weight in configuration and

features criteria.

E. Current DSLR market desirability analysis

With the HDM structure and desirability function developed, current DSLR market desirability value can be analyzed. By utilizing the Technology Value (TV) equation mentioned in previous section, the specification data for each camera model can be referenced to desirability category and mean value can be obtained for calculating total technology value score.

1. Canon Desirability Results and Analysis

For overall, the most desirable model is Canon EOS 6D with 65.88% desirability score. This finding, as shown in Figure 15, applies to male sub group as well, whereas Canon EOS100D (64.92%) seem to be a little more attractive to the female sub group. It may be implied that middle class of Canon model are more desirable for all experts and male sub group. The female sub group tends to reflect desirability on budget and weight consideration, so that the beginners class Canon EOS100D is selected as the most desirable model.

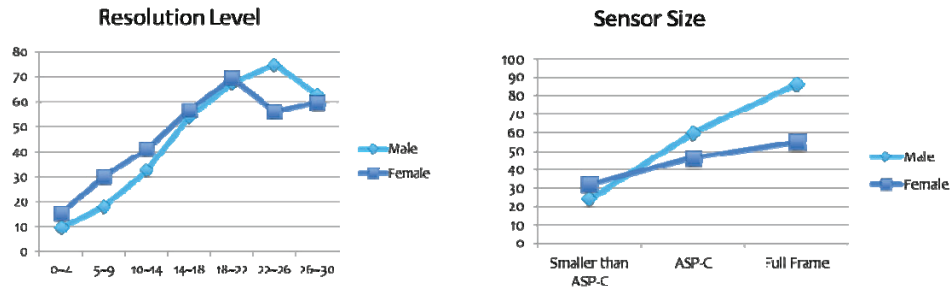


Figure 14: Resolution Level and Sensor Size Desirability comparison between female and male sub group

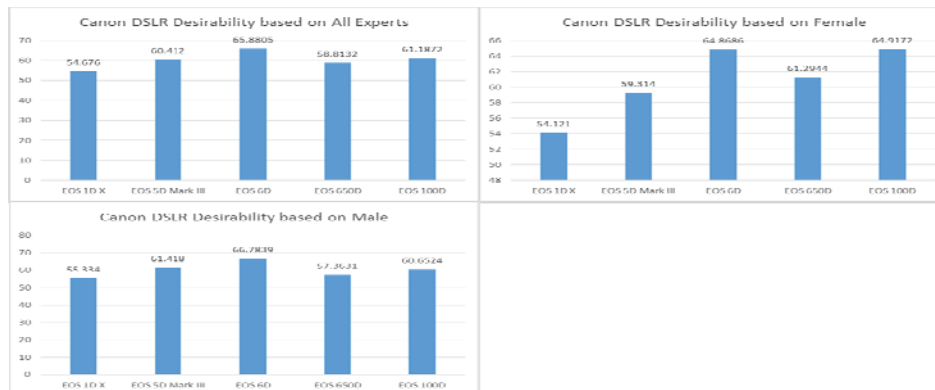


Figure 15: Canon Desirability Result

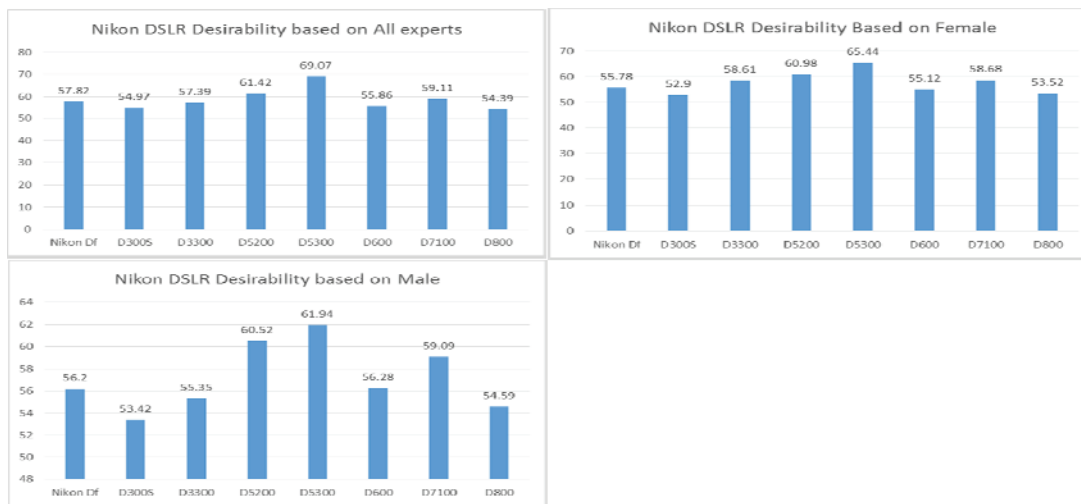


Figure 16: Nikon Desirability Result

2. Nikon Desirability Results and Analysis

The result indicates that Nikon D5300 is considered as the most desirable model with 69.07%, 65.44%, and 61.94% desirability score perceived by overall, female, and male sub group respectively. This may imply that Nikon beginner's class balances all the requirements listed in entire sub criteria.

3. Sony Desirability Results and Analysis

Based on the overall desirability, as shown in Figure 17, Sony α 65 accounts for 62.62% and is the most desirable model for all the experts. From the perspective of female, Sony α 65 and α 58 receive very close score. Meanwhile,

Sony α 65 is also the most desirable one from the viewpoints of male sub group. This may imply that "advanced beginner's" class is considered as the most desirable model among all range of choices.

4. Olympus and Pentax Desirability Results and Analysis

Pentax K-30 is selected as the most desirable model and accounts for 66.34%, 67.8%, and 65.9% desirability score in overall, female, and male segments. Similar justification as Sony and Nikon, this beginner class model is recognized as more desirable than other Olympus and Pentax Models, which balance all the required criteria.



Figure 17: Sony DSLR Desirability Result

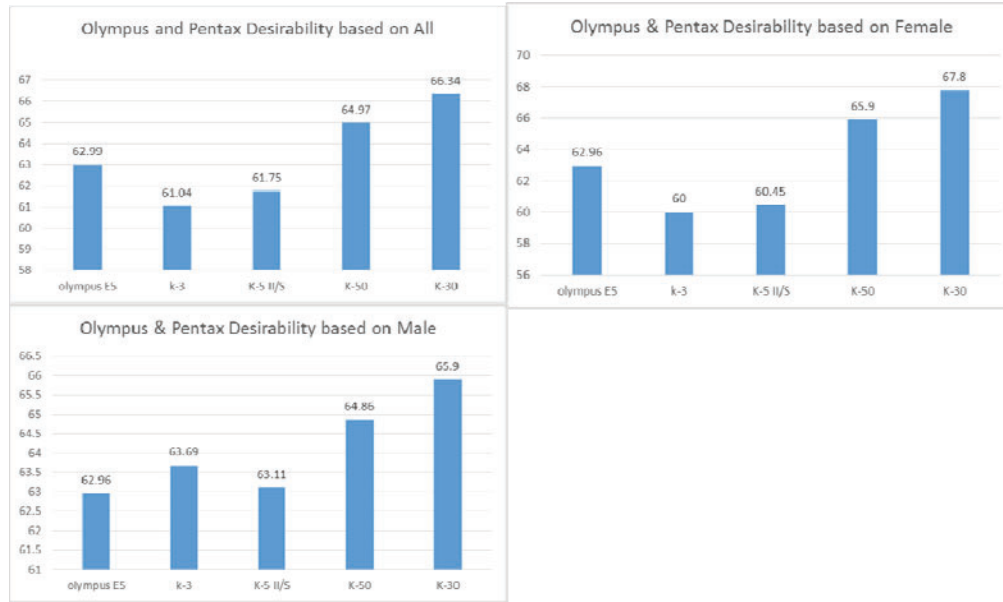


Figure 18: Olympus and Pentax Desirability Result

VI. CONCLUSION AND FUTURE WORKS

From the analysis from both of the HDM model and the Desirability Functions, the research group had found out the important factors when the 18~30 years-old college students to make decisions on picking up the DSLR cameras, and finding out the desirable camera models for the college students among different brands. The conclusions are as the followings:

- There is no disagreement within both of the male and female experts' groups. And there is no significant disagreement within the whole expert group for the 18~30 years-old college students when they are making decisions on picking up their DSLR Cameras.
- There are some different opinions between male and female experts' groups on certain categories or criteria. Female users would pay more attention on the color, weight, appearances than male users; while male users would pay more attention on features and configurations than female users.
- The first thing to be considered would almost be the budgets for the camera. And female users would like to consider more on camera bodies while male users would like to consider more on camera lens.
- From the HDM model weights, it seems like some of the popular new features as bigger monitor screens, autodyne (self-shutting), and wireless connections were not as attractive to college users as the manufacturers expected. There might be some reasons from the competitions from the smartphones of the marketplace.
- Male users would also pay attentions on how the camera looks like.
- These specific differences also lead to the different desirable camera model to male and female users.

- The camera manufacturers might use the differences between male user and female users to build up the camera models which would attack their interests in different ways in the future to the market.

Since this HDM model is more likely to be used for a broader and general camera marketplace, there might be some explores and future works to be done with the decision model as the followings:

- Getting more data from more users, and do different analysis by divided them into different groups as age groups, nations, income status, etc. There might be still different opinions on certain criteria.
- Explore this decision model to a general camera users, not only for DSLR camera users.
- The model can be extended to more specific potential customers to gather more detail information. For example, dividing the experts into beginner photographers and professional photographers to gather target information.
- DSLR in different level can be separated to gain score from the model. And for each level, different recommendation can be showed to different customers.

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