**To:** Mr. Arvindvivek Ravichandran

**From:** Team E4

**Subject:** Choosing a method

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**Memo 2: Concept Creation and Selection**

The team, E to the Fourth, has come up with several solutions to the project put before it. The group has worked together to come up with what the customer’s desires are. They have created an objective tree and a functional model to help make the completion of the project easier. They have come up with a morphological matrix and out of that came four concepts of how to complete the project. They have created a Pugh chart and decision matrix to help decide on which concept is the best for completing the project.

The first thing the group had to address, when it was trying to create the original concepts, were what the customer’s needs and requirements are and what the group wanted the device to be capable of. To organize this process the group put all the criteria into the table below (Table 1). This allowed the group to understand the minimal functionality that the machine had to achieve.

|  |  |
| --- | --- |
| **Requirement / Need** | **Source** |
| Energy must be stored human energy or electrical energy | Project Page |
| Must fit in 36'' by 36'' by 72'' box | Project Page |
| Maximum voltage is 30V | Project Page |
| Must launch projectiles that have a mass of under 100g | Project Page |
| Be automated or controlled remotely | Project Page |
| Accurate | Team |
| Cheap to produce | Team |
| Easy to use | Team |
| Has large capacity | Team |
| Safe to use | Project Page / Team |

Table 1 – Requirements/Needs

For the group’s morphological matrix they labeled each column as separate important functions; scoring points, converting potential energy to kinetic energy, processing user input, and storing/supplying energy (Table 2). Then each row consists of four potential solutions and how they answer each column; RC Helicopter, Ramp, Catapult, and Spring Cannon

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Score Points | Convert to Kinetic Energy | Process Input | Store/Supply Energy |
| Solution 1 | RC Helicopter | Drop | Remote control | Hydrogen Fuel Cell |
| Solution 2 | Conveyor Belt | Shoot | Switch | Battery |
| Solution 3 | Catapult | Push | Pull String | Mechanical |
| Solution 4 | Spring Cannon | Pull | Timer | Gravity |

Table 2 – Morphological Matrix

The objective tree shows the main goals for the design project (Figure 1). The three main objectives are safety, throwing projectiles, and being creative. The safe category is further narrowed down to control. The throwing projectiles goal is split up into being accurate and fast. The accurate objective is then narrowed down to being precise. The creativity objective is split into being original and being aesthetically pleasing which is then narrowed down to having our team logo and name on the device.



Figure 1 – Objective Tree

The functional model shows the process that the device does through to function (Figure 2). First it takes electrical energy and activation from the user. Then it regulates the energy and converts it to potential energy, while processing user input. Third, it converts the potential energy to kinetic energy. Finally it scores points.



Figure 2 - Functional Models

The Pugh chart (figure 2) compiled the group’s preliminary concepts together to get an initial estimate of which design accomplished the team’s goals the most effectively. The team chose the spring cannon to be the baseline because it was believed to be the most average out of all the available options. The criteria was selected from the requirement table and simplified into one word descriptions to best accommodate what the group’s overall desires were.

Cost was chosen due to the limited budget. The Points category was chosen because of the requirement of the machine to be able to score the most points. Simplicity was desired due to the lack of time and the danger of a complex design not functioning effectively. Capacity was needed to carry the most of the point scoring objects. Finally, Creativity was chosen due to the originality requirement found in the requirements table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Spring Cannon** | **Conveyor** | **Catapult** | **Helicopter** |
| **Cost** | 0.00 | 0.00 | 1.00 | -1.00 |
| **Points** | 0.00 | 1.00 | 0.00 | 0.00 |
| **Simplicity** | 0.00 | 1.00 | -1.00 | -1.00 |
| **Capacity** | 0.00 | 1.00 | 0.00 | 1.00 |
| **Creativity** | 0.00 | 1.00 | 1.00 | 1.00 |
| **Total** | 0.00 | 4.00 | 1.00 | 0.00 |

Table 3 - Pugh Chart

The group discussed and voted on the scores of each concept for each of the criteria. The totals lead the group to believe that the conveyor design was the most feasible and interesting solution for the problem. The results of the process can be seen above (Table 3). Since there was disagreement over whether or not this design would achieve the main goals of the group had to consider the Pugh chart an inadequate method of selecting the final design for two reasons. The first reason is that the criteria were not weighted based on each member’s perception of each requirement’s importance. The second reason the Pugh chart was not the best method to select the concept is because it made the assumption the Spring Cannon was the most average solution, which is incorrect. So the group decided a better method to select the design was the decision matrix.

The decision matrix accomplished the group’s desire to compare each concept because it was more precise than the Pugh chart in comparing the needs, requirements, and concepts. The group decided to add the additional criteria of safety and weight to the decision making process due the requirements of the lab and the ability to transport the device reliably.

After each group member took their stand on what the weight of each criterion needed to be, the group came to the conclusion that the group desired the maximum amount of points possible and that the number of objects the device could get in to the goal in the least amount of time was the groups primary objective. That is why capacity was such a major concern.

After each member discussed the rating of each concept for each criterion, the group used the total scores and found that the conveyor was still the best overall concept. The results of our process can be seen below (table 4).

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Importance | | R.C. Helicopter | | Conveyor | | Spring Gun | | Catapult | |
|  | **Raw** | **Weighted** | **Raw** | **Weighted** | **Raw** | **Weighted** | **Raw** | **Weighted** | **Raw** | **Weighted** |
| **Max. value** | 5 | N/A | 5 | N/A | 5 | N/A | 5 | N/A | 5 | N/A |
| **Min. value** | 1 | N/A | 1 | N/A | 1 | N/A | 1 | N/A | 1 | N/A |
| **Safety** | 4 | 0.190 | 4 | 0.762 | 4 | 0.762 | 3 | 0.571 | 2 | 0.381 |
| **Weight** | 2 | 0.095 | 5 | 0.476 | 3 | 0.286 | 4 | 0.381 | 3 | 0.286 |
| **Cost** | 4 | 0.190 | 1 | 0.190 | 3 | 0.571 | 3 | 0.571 | 3 | 0.571 |
| **Simplicity** | 3 | 0.143 | 4 | 0.571 | 4 | 0.571 | 2 | 0.286 | 4 | 0.571 |
| **Capacity** | 5 | 0.238 | 2 | 0.476 | 5 | 1.190 | 2 | 0.476 | 2 | 0.476 |
| **Creativity** | 3 | 0.143 | 5 | 0.714 | 5 | 0.714 | 3 | 0.429 | 3 | 0.429 |
| **Totals** | 21 | 1.000 | 21 | 0.638 | 24 | 0.819 | 17 | 0.543 | 17 | 0.543 |

Table 4 - Decision Matrix

This method made it clear that the most effective concept was the Conveyor, so the group decided that due to the overwhelming amount of evidence in its favor that the Conveyor design would be the concept the group used to solve the problem.

The group’s concept sketches show the four different solutions that were used in the morphological matrix (Attachment 1). The RC Helicopter is a remote controlled helicopter that would have a mesh carrier that would transport the projectiles. The conveyor belt model has a conveyor belt on top of a stationary base that can move for different targets and has a funnel to store the projectiles in. For the catapult, it has a latch to release the arm in order to launch the projectiles and then an upright bar to stop the arm after launch. The group’s final concept was a spring cannon where the projectiles are loaded onto a spring in the cannon that would then launch them towards the target.

In conclusion, E to the Fourth, has worked hard together to come up with the best possible solution to the project. The group decided that building a conveyor belt would be the best solution based on what the customer’s needs are. The group also based their decision by using the Pugh chart and functional model which the conveyor belt scored very high on compared to the other concepts. The group believes they have made the best possible solution to achieve their goal.

