Do Six-Hats and Myers-Briggs Preferences Based Team Formation Strategies Really Produce More Effective Design Teams?

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Abstract

Two proposed team-forming algorithms (one based on DeBono's Six Thinking Hats preferences for group interactions and the other based on Myers-Briggs Personality Preferences) based on the desire to have a range of psychological/ communication/ interpersonal skills present on a team were evaluated. The performances (testing the artifact, critiquing the artifact, characterizing the team's overall performance on the project) of forty, self-formed, design teams were evaluated. The team performances were then compared based on the degree to which the team's makeup satisfied the two algorithms. Team performances were the poorest for the teams whose membership satisfied the algorithms and actually become increasingly better as team makeup deviated more from that described by the algorithm. It is concluded, at least for the skill sets considered here, that heterogeneity (at least as characterized by DeBono and Myers-Briggs) had an adverse effect of team performance.

Introduction

In a paper presented at the 2000 ASEE Annual Conference, Jensen et. altera[1] proposed two strategies for forming more effective teams. (A literature review of forming teams based on personality typing is also presented in that paper.) One of these strategies was based on the "Six Thinking Hats" formulation of Edward DeBono[2], and the other was based on grouping specific personality types as determined with Myers-Briggs Type Indicators (MBTI)[3,4]. In that paper the authors claimed that specific goals in team formation, e.g., providing creativity, providing mixed positive and negative feedback, and providing team leadership, were more likely to be accomplished by forming teams based on their team forming strategies. These strategies were implemented using selection algorithms which specified the grouping of specific personality types or preferences for a team. Their "validation" consisted of comparing the team "grades" for ten teams formed from 50 students. These ten teams represented six different categories of team formation. In the current study these algorithms are applied after the fact to design teams in our sophomore "Introduction to Design" course in the Department of Mechanical Engineering. Each semester self-selected teams of mostly four students work on a semester-long design, fabricate, and test project. There are three aspects to the evaluation of this design activity: testing (performance), design critiques, and group communications (reports). The teams' performances in these categories were all evaluated first, and then it was determined which teams' make ups satisfied the selection algorithms for the six thinking hats and MBTI preferences proposed by Jensen. Teams from the classes in the fall of 2004 and the spring and fall of 2005 have been used (involving 158 students in 40 teams), and it is generally seen that the "unstructured" teams out performed the teams satisfying the selection algorithms by 10 to 20% in the three categories (testing, design critique and over all project grade). Team performances as a function of team "disorder" (to be defined) are also presented.

Background

Generally heterogeneity (e.g., in skill, knowledge, and personality types) is viewed as a positive for team formation since it encourages considering a problem from different perspectives which can result in more solution options. However, heterogeneous teams tend to have more conflict and indecision and hence are slow to produce results[5]. On the other hand homogeneous teams seem to act faster but with less creative solutions.

DeBono's Six Thinking Hats

DeBono's work describes six ways of thinking and interacting with the world. He identified six different styles of communicating and assigned each a "role", hence a different color hat. A summary of the six-hats roles, each with seven associated, descriptive statements is given in Table 1. Jensen et altera[1] converted this summary into a 42-statement survey asking the student to indicate the degree of his/her agreement with each of the statements on a six-point scale from never true to always true. This survey was administered to and completed by all the students participating in the current project.

Myers-Briggs Type Indicators and Preferences

Myers-Briggs Type Indicators were developed in the 1950s by the mother-daughter team of Isabel Myers and Katherine Briggs based the work of Carl Jung in the early part of the 20th century. There are many descriptions [3-9] of the MBTIs, but a brief overview is given here.

The thesis is that people have preferences, or preferred ways of doing things, but a preference doesn't mean that one is constrained to only way of behaving. The MBTI testing locates ones preferences in four different preference continua. A debate continues about the reasons for these preferences, e.g., nature or nurture, and the permanence of these preferences. However, the fact remains that at a given time most of us have specific preferences, some more pronounced than others, even though we may be "forced" to behave in a contrary matter. Also, there seems to be a "degree" of preference in that people may have a "strong" or "weak" preference for a certain type of behavior. Sometimes the preference is so weak as to be essentially non-existent.

These preference continua are defined with respect to ones desired behavior in the following four areas: Extraversion (E) as opposed to Introversion (I); Sensing (S) as opposed to Intuition (N); Thinking (T) as opposed to Feeling (F); and Judging (J) as opposed to Perceiving (P).

Table 1: Summary of the Six-Thinking Hats Communication Styles[2]

White Hat	**Red Hat**
• I focus on objective facts. • I enter into a discussion with preconceived ideas on a solution. • I seek to know that facts of a situation. • I seek to know the statistical evidence concerning a decision. • I try to think totally objectively about a situation. • I seek to differentiate between facts and opinions. • I am more interested in facts than opinions.	• My feelings sway my decisions. • I have good intuition. • I often have hunches about the best decision. • My personal opinions play a significant role in my decision making process. • I listen to my emotions when making decisions. • I am suspicious of other people's decision making process. • I think emotions should play a significant role in decision making.
Yellow Hat	**Black Hat**
• I usually see the positive side of things. • I can often see the good parts of even a bad idea. • I am usually optimistic that a new idea will work. • I tend to see the valuable contributions in people's ideas. • I believe that most new ideas have significant value. • I usually "look on the bright side" of a problem. • My comments are usually positive and constructive.	• I can quickly see why an idea will not work. • I often can tell an idea will not work by judging from past experience. • I like to play the "devil's advocate." • I can usually see the pitfalls in an idea. • I can readily detect poor logic in someone's argument. • I find it easy to be critical of other's ideas. • I am often pessimistic of other's ideas.
Green Hat	**Blue Hat**
• I am creative. • I often generate new ways of thinking about a problem. • I easily think "outside the box." • I am good at finding new approaches to solving a problem. • I am constantly thinking of alternatives. • I am not likely to settle for the "status quo." • I can easily generate new concepts.	• I like to lead the problem solving process. • I tend to think as much about the problem solving process as the problem itself. • I focus on the big picture, summarize, and draw conclusions. • I find myself trying to keep the groups focused. • I tend to try to optimize the group's problem solving process. • I often help the groups clearly define the problem. • I often find myself orchestrating the group.

<u>Extraversion and Introversion:</u> (feelings about people) The person preferring extraversion receives energy from interacting with people while the person preferring introversion receives energy from his/her "space".

<u>Sensing and Intuition:</u> (feelings about information) The sensing person prefers concrete information, "the facts", and the "here and now". The person preferring intuition prefers the abstract and the "what ifs" and is probably bored the details.

Thinking and Feeling: (feelings about decision making) The thinking person bases his/her decisions on logic and prefers "rules" regardless of the uniqueness of the situation. The feeling person prefers to make decisions based on the situation and is seeking to satisfy everyone.

Judging and Perceiving: (feelings about life style) The judging person prefers a planned and orderly life and is uneasy when faced with the prospect of a big decision, desiring to have a speedy resolution. The perceiving person is spontaneous, flexible and adaptable; he/she gathers as much input as possible when faced with a decision but usually puts it off until the last minute.

The MBTI is therefore a four-letter code constructed from the first letter (except intuition is designated as "N" to avoid confusion with introversion) of each of the sets above indicating ones preferences, e.g, ESTJ is an extroversion, sensing, thinking, and judging personality.

A version of the Myers-Briggs Type Indicator test, the Keisey Temperament Sorter[4], has been administered in the Introduction to Design course each semester since 1991. For the three semesters covered by this project, all students completed the Sorter survey.

Team Formation Strategies

Jensen et altera[1] have proposed the following algorithm for forming a "Six-Hats Team", that is, one with sufficient diversity to be an effective team. The team should be composed of at least one member with each of following primary hats (i.e., most preferring the associated communication style as determined from the survey): "Green", "Yellow" and "Black" and at least one member with a primary or secondary (second choice) "Blue" hat. This combination is intended to combine creativity ("green"), both positive ("yellow") and negative ("black") feedback, and leadership ("blue").

With similar logic Jensen et altera[1] also propose an algorithm for forming a "MBTI Team". The team should have at least one member with a preference for J, for P, for T, and for F and either for EN or alternatively for IN if someone else prefers E.

Peer evaluations were administered at the end of the semester using the autorating method[10] in the courses. In this method students rate their team members on a qualitative scale based on their team citizenship, i.e., how well each member fulfilled his responsibilities to the team. The students are told not to rate their teammates on academic ability or on their total contribution to the project, but simply whether or not or to what degree they did what was expected of them. The rating of each team member is then normalized with respect the team average. The root-mean-square of the individual ratings about the team average is determine and used as measure of the team's ability to work effectively together.

In the Introduction to Design class about half of the semester grade is based on a two-month "major design project". (For more details on this class and the projects see

Reference 11.) For these projects (a different one in each class) each team had to design, fabricate and test competitively a device. Evaluation of the testing is done through the use of a publicized figure of merit. The device itself is evaluated by the instructor based on a publicized rubric which is discussed in class:

- Concept (20%): rationality of approach and selection of design concept
- Creativity (20%): application of the concept
- Performance and robustness (20%): based on the testing and repeatability
- Esthetics (15%): craftsmanship and overall appearance
- Description (15%): operations manual submitted with the project
- Attention-getting (10%): measure of interest generated during testing.

Teams also submit two progress reports, a final report, and give a formal oral presentation.

For the purposes of this paper it was decided to “rate” the teams on three criteria: performance on testing (a normalized figure of merit); instructor evaluation of the device; and the project grade which is the sum of the first two (totaling about 60% of the grade) plus the communications component. These evaluations were all converted to a “gpa” scale with 4.0=A, 3.0=B, 2.0=C, etc. Also, grades above 4.0 are possible in all aspects of the grading. Descriptions of the three projects and samples of some of the resulting projects are given in the Appendix at the end of this paper.

Results

As noted above, the results from three classes were combined to produce the data used in this study. One hundred fifty-eight students working on forty teams were included. That data is summarized in Table 2.

The leftmost column headed with the “#” symbol indicates the number of team members. Thirty-two teams had four members; five teams had three members; and three teams had five members. The next three columns are the grades for the testing, design evaluation, and the final project grade (4.0=A. 3.0=B, etc.). The next two columns indicate the number of “DeBono hats” missing from each team. The column headed by “Ref 1” are the “hats” missing according to the algorithm of reference 1, as reviewed in the last section of this paper. The sixth column indicates the number of “hats” missing from the total of six. The next two columns indicate the number of MBTI preferences missing from the team, according to Jensen’s algorithm in the seventh column and then the number missing from the total set of eight in the eighth column. The ninth column is the root-mean-square deviation of the individual peer evaluations for each team with respect to the team’s mean. Since this value is somewhat biased against larger teams, the last column is the root-mean-square divided by the square root of the number of team members less one. (There is no good reason for selecting this particular “normalizing” factor, but its choice does really not have much to do with the significance of the results.)

Table 2: Data for Forty Teams

	Performance Measures			Hats Missing		Pref Missing		Peer Evaluations**	
#*	Test	Design	Grade	Ref 1	Total	Ref 1	Total	Rms	Rms/√(#-1)
3	1.90	3.87	2.80	2	4	1	1	0.241	0.170
4	2.01	3.94	2.55	1	3	2	2	0.101	0.058
4	2.99	3.44	3.49	2	4	2	2	0.132	0.076
4	3.78	3.26	3.14	2	4	3	3	0.071	0.041
4	2.73	3.50	3.02	2	4	2	2	0.766	0.442
4	5.47	3.39	3.98	1	3	3	3	0.026	0.015
4	4.35	4.67	3.75	2	4	3	3	0.066	0.038
4	0.88	1.66	2.44	1	3	1	1	0.101	0.058
4	3.45	3.57	3.43	1	2	1	1	0.213	0.123
4	3.85	0.86	2.56	1	3	1	1	0.224	0.129
4	2.37	1.41	2.31	1	2	0	1	0.216	0.125
5	1.04	1.44	2.03	1	1	1	1	0.762	0.381
5	3.89	2.90	3.12	0	0	1	1	0.352	0.176
4	4.26	4.06	3.06	0	1	1	1	0.196	0.113
3	3.10	3.26	3.48	1	3	3	4	0.425	0.301
3	4.06	2.03	3.24	2	4	1	2	0.603	0.426
4	4.35	4.13	4.05	0	2	1	1	0.074	0.043
4	4.17	2.77	3.24	2	4	0	0	0.074	0.043
3	3.05	2.40	3.23	1	2	2	3	0.099	0.070
4	1.05	0.83	2.06	0	2	1	1	0.459	0.265
4	3.96	3.17	3.01	1	3	2	3	0.142	0.082
4	4.20	3.36	3.96	1	2	0	2	0.162	0.094
4	3.21	2.87	2.96	3	5	2	1	0.099	0.057
4	4.30	3.44	4.00	2	3	2	2	0.040	0.023
4	2.61	0.87	1.89	2	4	0	0	0.227	0.131
4	2.55	3.53	3.02	2	4	1	1	0.282	0.163
4	2.19	2.33	2.61	0	0	0	0	0.753	0.435
5	2.75	3.67	2.82	1	3	1	2	0.789	0.395
4	4.48	3.93	3.99	3	4	1	1	0.162	0.094
4	2.74	1.40	2.90	0	1	1	1	0.406	0.234
4	4.11	3.00	3.03	1	3	3	3	0.045	0.026
4	3.34	2.87	3.23	2	4	2	2	0.071	0.041
4	1.68	3.00	2.98	1	2	1	1	0.040	0.023
4	2.86	3.53	3.50	2	4	0	0	0.057	0.033
4	3.94	3.67	3.97	1	3	0	0	0.241	0.139
4	4.06	2.27	3.62	2	4	0	0	0.171	0.099
4	3.53	2.67	3.44	2	3	2	3	0.114	0.066
3	3.37	2.93	3.41	2	3	3	2	0.099	0.070
4	2.89	3.60	3.00	1	2	3	2	0.069	0.040
4	4.19	2.33	3.41	2	3	3	4	0.103	0.059
* Number of students on team									
** Root mean square of team peer evaluation relative to team mean									

A series of results are presented in Tables 3 through 6. In Table 3 the teams are grouped by the degree to which they satisfy the Jensen algorithm for team formation based on DeBono's "hats." In the first column it is shown that 6 (of the 40) teams satisfied the algorithm and those teams scored an average of

- 3.08 (out of a 4.0, a "B") for the artifact testing portion of the project,
- 2.61 (out of 4.0, a "B-") for the artifact evaluation portion of the project, and
- 2.97 (out of 4.0, a "B") for the overall project grade.

The columns to the right list results for teams that increasingly violate the algorithm. These teams' performances do not decrease but in fact significantly increase in some cases. The thirty-two teams missing one or two "hats" actually outperform the "perfect" teams by an average of over 10%. The two teams with very little variation (missing three "hats") actually outperforms the "perfect" teams by over 30%.

Table 3: Team Performance as a Function of Missing "Hats" on the Team according the Jensen's Algorithm.

No of missing Hats (Ref 1)	0	1	2	3
No. of Teams	6	16	16	2
Average Testing Score	3.08	3.05	3.42	3.85
Average Design Evaluation	2.61	2.84	3.01	3.40
Average Project Grade	2.97	3.05	3.26	3.48

Table 4 shows similar results when all the missing "hats" are counted. The twenty-seven teams with three, four and five missing "hats" outperform the "perfect" teams by an average of over 20%.

Table 4: Team Performance as a Function of Total Missing "Hats" on the Team.

Total no. of missing hats	0	1	2	3	4 or 5
No. of Teams	2	3	8	13	14
Average Testing Score	3.04	2.68	2.88	3.64	3.36
Average Design Evaluation	2.62	2.30	2.79	2.94	3.10
Average Project Grade	2.87	2.66	3.13	3.24	3.21

Tables 5 and 6 present similar (but not so dramatic) results for team performance but as a function of the missing MBTI preferences -- first according to the Jensen algorithm (Table 5) and then for all missing preferences (Table 6).

With only a few exceptions, the results from Tables 3 through 6 indicate that the more nearly homogeneous teams are producing better results than the more heterogeneous ones that seem to have better "hat" and "preference" balance.

Table 5: Team Performance as a Function of Missing MBTI Preferences on the Team according the Jensen's Algorithm.

No. of missing MB Preferences (Ref 1)	0	1	2	3
No. of Teams	9	14	9	8
Average Testing Score	3.32	2.82	3.24	3.91
Average Design Evaluation	2.64	2.67	3.17	3.31
Average Project Grade	3.17	2.03	3.21	3.40

Table 6: Team Performance as a Function of Missing MBTI preferences on the Team.

Total no. of missing MB Preferences	0	1	2	3 to 4
No. of Teams	6	15	9	10
Average Testing Score	3.31	2.85	3.21	3.83
Average Design Evaluation	2.57	2.66	3.18	3.20
Average Project Grade	3.14	3.14	3.19	3.44

One last issue is now addressed. As noted, peer evaluations were conducted using the autorating method. Normally successful teams have good input from all members, and it would seem logical that all members would receive similar and high peer evaluations. To check this hypothesis, Table 7 was constructed in which the performances of the teams were grouped according to the level of non-uniformity of their peer evaluations. The parameter utilized, related to the rms variation of the peer evaluations for one team, has no particular absolute meaning, but rather only serves as a parameter whose relative values can be used to sort out the teams by their level of ability to work together. In the first column of Table 7, eleven teams are indicated as having their "rms parameter" below 0.05, and their performances are clearly more than 10% above those in the next group, with an "rms parameter" between 0.05 and 0.10. This trend continues, and it is seen that the eleven most "functional" teams outperform the eight most "dysfunctional" teams (based the "rms parameter") by a average of more than 40%.

Finally, Figure 8 is an attempt to determine the level of team "dysfunction" as defined above as a function of the degree to which the team satisfies team formation algorithms previously defined. The first two rows of Table 8 are the same as those in Table 7. In the remaining the rows, team performance has been replaced by average number of missing "hats" or preferences for the teams in each category. As seen in the table, the more functional teams generally have a greater number of missing "hats" and preferences than do the less functional teams.

Table 7: Team Performance as a Function of Team's Ability to Work Together as Determined from the Variations in the Peer Evaluations.

Range for rms/√(#-1)	<0.05	0.05 to 0.1	0.1 to 0.2	0.2 to 0.5
No. of Teams	11	12	9	8
Average Testing Score	3.75	3.33	3.20	2.46
Average Design Evaluation	3.42	2.93	2.75	2.31
Average Project Grade	3.45	3.29	2.91	2.77

Table 8: A Comparison of Team's Ability to Work Together and number of Missing Hats and MBTI Preferences

Range for rms/√(#-1)	<0.05	0.05 to 0.1	0.1 to 0.2	0.2 to 0.5
No. of Teams	11	12	9	8
Avg. Hats missing Ref 1	1.45	1.75	1.11	0.88
Avg total Hats missing	3.20	3.25	2.55	2.25
Avg MB Preferences Missing (Ref 1)	1.91	1.41	0.55	1.37
Avg MB Preferences Missing	1.91	2.00	0.78	1.65

Discussion

The purpose of this study was to evaluate two proposed team forming algorithms that purported to assure that the teams would have the variety of personalities and the communication and interpersonal skills needed to assure good team performance. This study actually demonstrated the opposite. The teams formed according to the algorithms under-performed compared to the other teams in the study that did not meet the conditions of the algorithms. Further it appears that not only did these "special" teams under-perform, they had more difficulty getting along than the other teams as might be expected with heterogeneous teams.

Conclusions

Two team-forming algorithms were tested and found to be ineffective. The algorithms were an attempt to assure a certain type of heterogeneity on the teams. In fact, the current results demonstrated the opposite effect --the more similar the team members in these area, the better the team performance. Hence these results support the proposition that homogeneous teams (based on personalities, communication and interpersonal skills) tend to outperform heterogeneous teams.

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Appendix: Project Descriptions

Fall 2004 Project Statement:

Design, fabricate and test a device that will "throw" at least five golf balls in eight tries within three minutes through two openings (four balls aimed at each) from a distance of at least five feet. The openings are both 5.0 ± 0.2 inches in diameter with centerline distances at 20.0 ± 0.5 inches and 40.0 ± 0.5 inches above the floor. The device shall weigh less than ten pounds (the lighter the better) and shall fit within a cube, 30 inches on an edge before "deployment." There are no restrictions on the type of energy used, but there can be no external (outside the allowed volume) power source. However, designs using gravitational energy will be viewed more favorably than those using other forms of energy. Devices using "mechanical" energy will be viewed second most favorably. Devices that use "excessive" energy (or power, e.g., excessive velocities) will be penalized.

Specifically, the goal is to maximize the figure of merit, FM, defined as

$$FM = 4*N + 3*(10 - \mu)$$

where

N is the number of times the golf ball successfully pass through the opening ($N \geq 5$).

μ is the weight of the device in pounds ($0 \leq \mu \leq 10.0$).

Example solutions are shown in Figs. A.1 and A.2. The testing set up is shown in Fig. A.2. For the Final Testing the two smaller holes were the target. The larger (center) hole was utilized for the Initial Testing.

Figure A.1: Torsion Spring Solution

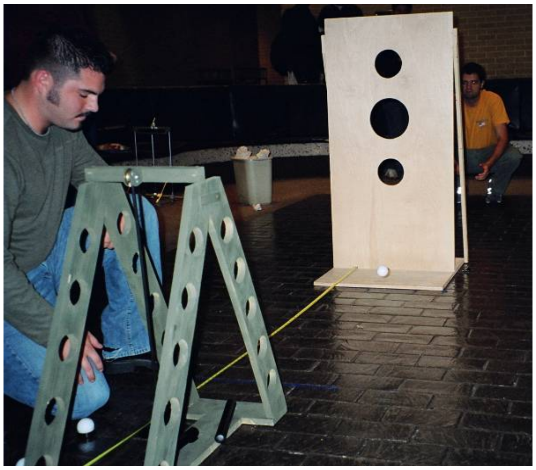

Figure A.2: Testing Set Up and Pendulum Solution

Spring 2005 Problem Statement:

Design, fabricate and test a device that will "propel" a golf ball over an obstacle (wall) such that the ball lands within two inches of the center of a "target" in a horizontal plane. The device shall weigh less than ten pounds (the lighter the better) and shall fit within a cube, 30 inches on an edge before "deployment." For the Final Testing each team will select one of four wall heights (the higher the better), will place the target as close to the wall as they chose (the closer the better, but with at least 13 inches between the base of the wall and the center of the target), and attempt to land the ball within two inches of the center of the target. The requirement is to be successful in hitting the 13-inch diameter target at least four times in six attempts. During operations the ball may not reach a height of more than eight feet above the horizontal plane of the target and the initial placement of the ball must be at least three feet from the wall and no more than eight inches from the horizontal plane on which the target rests.

There are no restrictions on the type of energy used, but there can be no external (outside the allowed volume) power source. However, designs using gravitational energy will be viewed more favorably than those using other forms of energy. Devices using "mechanical" energy will be viewed second most favorably. Devices that use "excessive" energy (or power, e.g., excessive velocities) will be penalized or disqualified.

Specifically, the goal is to maximize the figure of merit, FM, defined as

$$FM = 20*(N - 4) + 2*(16 - D) + 4*(10 - \mu) + 0.5*(24 - L) + 0.75*H \qquad (1)$$

where

N is the number of times the ball lands on the target in six attempts ($N \geq 4$),

D is the sum of the "off target" distances for the best four attempts (e.g., the distance between the center of the target and center of the ball's impact) (D is measured in inches and for each attempt has possible values of 0, 3, 4, 5, or 6, respectively for landings in each of the sectors of the target counting outward.),

μ is the weight of the device in pounds ($0 \leq \mu \leq 10.0$),

L is the distance between the edge of the base of the wall stand and closest edge of the target (See Fig. 1) (L is in inches), and

H is height of the wall in inches.

Fall 2005 Problem Statement:

Design, fabricate and test an autonomous device that will separate as many as five golf balls from five ping pong balls, initially confined to a single (primary) container, by moving them into two separate (secondary) containers. The primary container is initially resting on a table with the device. There will be no external interference with the process once it is initiated. The balls must enter each secondary container in at least one-second intervals (at least one second between "ball deposits"), and the entire process has a time limit of 30 seconds. The device shall weigh less than ten pounds (the lighter the better) and shall fit within a cube, 30 inches on an edge before "deployment." For the Final Testing each team will select the number and type of balls to be placed in the primary container. It is required that at least two identical balls be placed in each of the secondary containers within 30 seconds. It is desired to transfer as many balls as possible (up to ten; five into each secondary container), as fast as possible, with a device weighing as little as possible.

There is no restriction on the type of energy used, but there can be no external (outside the allowed volume) power source. However, designs using gravitational energy will be viewed more favorably than those using other forms of energy. Devices using “mechanical” energy will be viewed second most favorably. Further, if multiple forms of energy are used, the greater the proportion of gravitational and/or mechanical energy the better.

Specifically, the goal is to maximize the figure of merit, FM, defined as

$$FM = G + P + 0.5*G*P - |G-P| - 2*(N-G-P) + 4*(10-\mu) + 0.1*(30-\tau)(G+P)$$

where

N is the total number of balls initially in the primary container ($N \leq 10$),

G is the number of golf balls successfully placed in the “golf ball” secondary container.

P is the number of ping pong balls successfully placed in the “ping pong ball” secondary container.

μ is the weight of the device in pounds ($\mu \leq 10.0$),

τ is the time for the run in seconds ($\tau \leq 30$)

Example solutions are given in Figs. A.3 and A.4.

Figure A.3: Spring lifter, size sorter, and pendulum timer

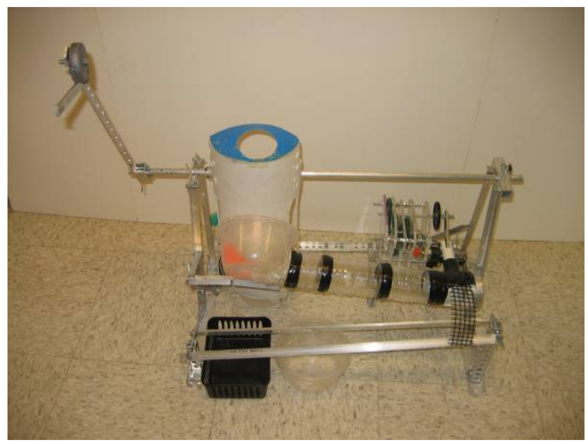

Figure A.4: Gravity lifter, size sorter, and electric timer