ADDRESSING THE EXISTENCE OF OVERCROWDING IN THE CAL POLY REC CENTER EXERCISE ROOMS

A Senior Project submitted to
the Faculty of California Polytechnic State University,
San Luis Obispo

In Partial Fulfillment
of the Requirements for the Degree of
Bachelor of Science in Industrial Engineering

by

Josue Alvarez
Robert Hemphill
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. FIGURES</td>
<td>2</td>
</tr>
<tr>
<td>II. INTRODUCTION</td>
<td>5</td>
</tr>
<tr>
<td>III. LITERATURE REVIEW</td>
<td>8</td>
</tr>
<tr>
<td>Possible approaches to the issue of overcrowding</td>
<td>8</td>
</tr>
<tr>
<td>Selected approach to the issue of overcrowding</td>
<td>9</td>
</tr>
<tr>
<td>Research of possible methodologies for chosen approach</td>
<td>10</td>
</tr>
<tr>
<td>Selected methodologies for chosen approach</td>
<td>13</td>
</tr>
<tr>
<td>IV. DESIGN</td>
<td>13</td>
</tr>
<tr>
<td>Identification of current hard constraints</td>
<td>14</td>
</tr>
<tr>
<td>Identification of current soft constraints</td>
<td>14</td>
</tr>
<tr>
<td>Work sampling data collection</td>
<td>15</td>
</tr>
<tr>
<td>Work sampling data analysis</td>
<td>17</td>
</tr>
<tr>
<td>Creation of recommended equipment layouts</td>
<td>18</td>
</tr>
<tr>
<td>Conservative design</td>
<td>19</td>
</tr>
<tr>
<td>Aggressive design</td>
<td>20</td>
</tr>
<tr>
<td>Creation of equipment inventory database</td>
<td>21</td>
</tr>
<tr>
<td>V. METHODOLOGY</td>
<td>21</td>
</tr>
<tr>
<td>VI. RESULTS</td>
<td>25</td>
</tr>
<tr>
<td>VII. CONCLUSION</td>
<td>28</td>
</tr>
<tr>
<td>VII. APPENDIX</td>
<td>30</td>
</tr>
<tr>
<td>VIII. REFERENCES</td>
<td>38</td>
</tr>
</tbody>
</table>
FIGURES

Figure 1 - 1st Survey Q7 on Overcrowding Effects and Impacts .............................................. 5
Figure 2 - 1st Survey Q5 Most Used Amenities ........................................................................ 6
Figure 3 - Clear Space Requirements ...................................................................................... 15
Figure 4 - 2nd Floor BIG - Data Collection Group Sequence .................................................. 16
Figure 5 - 1nd Floor BIG - Data Collection Group Sequence .................................................. Appendix
Figure 6 - 2nd Floor SMALL - Data Collection Group Sequence .............................................. Appendix
Figure 7 - 2nd Floor BIG - Cardio Equipment Utilization by Type ........................................... 17
Figure 8 - 2nd Floor BIG - Equipment Utilization ..................................................................... 17
Figure 9 – 1st Floor - Equipment Utilization ............................................................................ Appendix
Figure 10 – 2nd Floor SMALL – Equipment Utilization ............................................................ Appendix
Figure 11 - 2nd Floor BIG - Conservative Design ..................................................................... 19
Figure 12 - 1st Floor - Conservative Design ............................................................................. Appendix
Figure 13 - 2nd Floor SMALL - Conservative Design ............................................................... Appendix
Figure 14 - 2nd Floor BIG - Aggressive Layout ......................................................................... 21
Figure 15 - 1st Floor - Aggressive Layout .................................................................................. Appendix
Figure 16 - 2nd Floor SMALL - Aggressive Layout .................................................................. Appendix
Figure 17 - Rec Center Exercise Room Database ....................................................................... 22
Figure 18 - 2nd Floor BIG - Hypothesis Test Results ................................................................. 23
Figure 19 - 1st Floor - Hypothesis Test Results ........................................................................ Appendix
Figure 20 - 2nd Floor SMALL - Hypothesis Test Results .......................................................... Appendix
Figure 21 - Cost Analysis Calculation for Conservative Design .............................................. 24
Figure 22 - Cost Analysis Calculation for Aggressive Design .................................................. 24
Figure 23 - 2nd Floor SMALL -2 Proportion Hypothesis Test - Current vs Aggressive Layout .. 25
Figure 24 - 2nd Floor BIG Ratings for 3 Designs ...................................................................... 26
Figure 25 - 2nd Survey Q25 - Cost and Benefit Analysis ........................................................... 27
Figure 26 - 2nd Survey Q26 - Responses on Theoretical Scenario ........................................... 27
Figure 27 - 2nd Survey Q27 - Re-distribution of Rec Center Budget Feedback .......................... 28
EXECUTIVE SUMMARY

Cal Poly’s Rec Center is a facility that has been extremely popular among students ever since its initial creation many decades ago. Despite its popularity being a positive quality in most ways, it does ultimately yield a certain issue for the users of the facility; the issue of overcrowding. This senior project aimed to analyze the problem of overcrowding at the Rec Center and identify its most critical areas of impact. The first step in the project was to gather student feedback regarding the issue of overcrowding at the Rec Center through the execution of an online survey. The results of this survey enabled us to conclude that students agree that overcrowding is an issue at the Rec Center. The results of the survey also pushed us to narrow down our project’s scope to specifically address the issue of exercise room equipment usage imbalance, as this was noted to be the most impactful result of overcrowding. As such, all three of the Rec Center’s exercise rooms, identified in this report as the 1st floor, larger 2nd floor, and smaller 2nd floor exercise rooms, were to be included within our scope.

With these results, we moved forward with our project by executing a thorough work sampling study of the most critical equipment categories within each exercise room of the Rec Center. The results of this study were extremely significant, in that we found extreme polarity among the equipment usage percentages within each exercise room. Many pieces of equipment were found to be used less than 10% of the time, while other pieces of equipment were found to be used more than 90% of the time. With these results, we aimed to create alternative layout designs for each exercise room that heavily focused on the removal of the least used pieces of equipment and the duplication of the most used pieces of equipment. In order to offer not just one solution to this problem, we created two distinct alternative design structures, each with their own set of rules and severity of impact. The two alternative design structures created were the conservative design and the aggressive design. Through the usage of Icovia room planner software, we then created 3 top-down layouts for each of the Rec Center’s three exercise rooms. The 3 layouts created for each exercise room included the current layout, a conservative alternative layout, and an aggressive alternative layout.

Once these layout designs were created and polished in full, we set out to receive student feedback on our alternative designs through the execution of a second survey. In this survey, students were asked to compare and comment on both the current layouts of each exercise room, as well as our alternative layout designs. The results of this survey were a bit mixed, with most students either heavily favoring the current layouts or heavily favoring one of the proposed alternative layouts. Nonetheless, the alternative layouts were preferred over the current layouts overall, which allowed us to confidently make specific recommendations for each of the exercise rooms. Based on the results of this second survey, the conservative alternative layout is ultimately recommended for both the 1st floor exercise room and the larger 2nd floor exercise room. However, the aggressive alternative layout is ultimately recommended for the smaller 2nd floor exercise room, due to its overwhelmingly positive results from the survey. An additional focus of the second survey was to also gather student feedback regarding two possible forms of funding for our alternative layouts. The first form of funding considered was student funding through the implementation of an increased ASI quarterly fee. For the conservative alternative layout, the ASI quarterly fee was conservatively estimated to increase by 50 cents per student. For the aggressive alternative layout, the ASI quarterly fee was conservatively estimated to increase by 1 dollar per student. The second form of funding considered was Rec Center funding...
through the redistribution of their annual operational budget. Both forms of funding received significantly positive feedback in terms of implementation. Students, collectively, believe that the costs of student funding would be appropriate, if not low, given the impact of such implementations. In addition, students, collectively, believe that the redistribution of the Rec Center’s annual operational budget would be acceptable, so long as the programs that receive decreased funding are logical.

In addition to the design of alternative exercise room layouts, another major focus of our project was to create a simpler, faster, and more intuitive database for the Rec Center’s equipment inventory. The features of this database were made to be as tailored towards the needs of the Rec Center staff as much as possible, to make inventory management an easy and efficient process. While this focus of our project is less of a direct response to the issue of overcrowding at the Rec Center, it will make inventory management a much easier process for the Rec Center staff. As a result, future processes of equipment reallocation will be executed in a faster manner, reducing the down-time for the affected exercise rooms. The final product of our database was created in Access, and included, but is not limited to, major features such as product category filtering, on-the-fly equipment search capability, the ability to add/delete/edit equipment, and many forms of statistical analysis of the Rec Center’s equipment inventory as a whole.
Introduction

The Cal Poly Rec Center opened in 1993 to a campus that was eager for such a new and unique facility. With its impressive size and wide offering of amenities, it quickly became a central part of the school’s campus. These factors, in addition to Cal Poly’s ever-increasing student body and on-campus housing, ultimately led to severe issues of overcrowding and space limitations. The ASI Student Government, a student-based organization at Cal Poly, took action in 2007 by communicating directly with students regarding the issue of space at the Rec Center. The result of student feedback was overwhelming, with over 75% of students being in favor of renovation and expansion of the Rec Center. In response, the changes to the facility were carried out and completed by the beginning of 2012. Through hard work and student-based funding, the Rec Center was revamped for a better future; a problem fixed for the time being. Despite the immense benefit of the renovations that took place, a sizable elephant was left sitting in the bedroom of Cal Poly: the factors that led to the issue of overcrowding in the first place are still in existence.

In the fall of 2012, the year that the Rec Center’s renovations were completed, Cal Poly recorded a total of 18,679 students enrolled. By fall quarter of 2015, a mere three years later, the student body had increased by 12% to 20,944 in total. In addition, construction for more on-campus housing began in the fall quarter of 2015 and has an anticipated completion time of Summer, 2018. The expansion is estimated to increase on-campus housing capacity by roughly 23%. The numbers surrounding Cal Poly’s campus certainly don’t add up to a scenario in which the Rec Center is going to decrease in demand any time soon. Rather, the unfortunate outcome of overcrowding at the Rec Center seems imminent, if not already back in full. According to survey results shown in Figure 1, not only does the majority of the current student body believe that the Rec Center experiences overcrowding, but they consider it to personally affect their overall experience as a member.

---

**Figure 1** 1st Survey Q7 on Overcrowding Effects and Impacts

It is highly possible that the final solution to this problem will simply be to fund a second round of renovation and expansion, since this is, for the most part, the only way to eliminate the problem of overcrowding directly. However, it is vital to note that while the elimination of
overcrowding is a difficult task, the minimization of the effects of overcrowding is a course of action that is completely available to the Rec Center in the meantime. After all, overcrowding is only a problem in the context of its negative effects: decreased personal space and comfort, increased equipment unavailability, increased risk of damage to equipment, increased risk of injury, and so on and so forth. The clear majority of these undesirable outcomes takes place in the exercise rooms within the Rec Center, since per survey results shown below in Figure 2, the exercise rooms are the most used amenity within the facility. Thus, addressing and working to minimize the negative effects of overcrowding that takes place in these exercise rooms is where the efforts illustrated in this report come into play.

![Figure 2] 1st Survey Q5 Most Used Amenities

This report will describe the process of minimizing the impact that overcrowding has in the Cal Poly Rec Center exercise rooms, primarily through the design of optimal exercise room equipment layouts. The main goal of these layout designs is to maximize usability, while eliminating “wasted” space. In addition, a foundational motivation of our design is to maximize the number of layout decisions being sourced from hard data, while minimizing the number of layout decisions being sourced from assumptions or opinion. In relation to specific methodology, the primary objectives of our efforts in this project are listed below:

1. Gather student feedback regarding the subject of overcrowding at the Rec Center
2. Gather data on equipment usage percentages to identify high usage equipment and low usage equipment
3. Design optimal equipment layouts for the three exercise rooms in the Rec Center that maximizes usability, while minimizing “wasted” space
4. Design an equipment inventory database to expedite our design process, as well as any future design processes to come.

Meeting our first objective will be done through the execution of a survey that asks for student input about overcrowding, as a whole. The data gathered from this survey will serve two primary purposes:

1. Confirm directly through the student population that the problem of overcrowding in the Rec Center affects them in a significantly negative way.

2. Provide useful information for future data collection; information such as the busiest hours for exercise rooms, the equipment that is most in demand, etc.

Completion of the second objective will rely heavily on carrying out a thorough work sampling study that seeks to conclude what the most used pieces of equipment are, as well as what the least used pieces of equipment are. Consistency among sample data will be emphasized in order to minimize noise factors in the study as much as possible. Some of these noise factors include the variable movement of people within each data collection trial. With that, an optimal data collection method would be recording equipment utilization through a bird’s eye view of each exercise room, but due to privacy issues this method is unavailable. In addition, work sampling will be performed at peak usage hours as much as possible in order to properly represent what the usage distribution is like when overcrowding is most significant. The third objective will be accomplished by establishing layout design rules that determine the removal and addition of certain equipment within each exercise room. Most likely, more than one layout design for each exercise room will be created. Completion of the fourth objective will simply require access to the Rec Center’s current inventory database, combined with sufficient time to complete the design of the improved database.

With these factors considered, our final equipment layout designs for each of the three exercise rooms in the Rec Center will be as close to optimal as we can make them, given the scope and time of our project. Regarding the rest of this report, the Background section will go into detail the thought that went into our overall methodology for this project. The Design section will follow, for the most part, the sequence of the objectives listed above. The Methodology section will then describe our means of testing and refining our created designs. The Results section will summarize our most relevant findings from our design and methodology process. Finally, the Conclusion section will conclude the final outcome of our project’s efforts, as well as reflections regarding the proceedings of this project as a whole.

**Literature Review**

**Possible approaches to the issue of overcrowding**

When it comes to the process of minimizing the effects of overcrowding within an exercise room, there are many distinct approaches that can be taken. Given the scope’s capacity and time frame of our project, it was important to narrow our efforts down to only a few clear forms of approach, if not just one. With this in mind, the first step in setting up for our project was to
research as many potential approaches that have already been utilized by others in similar scenarios and compare them to each other as fairly as possible in order to conclude our approach of choice.

One of the first forms of approach researched involved the analysis of qualities such as sense of space, color, light, temperature, and sound. All of these aspects are potential areas of improvement that could significantly make an environment, such as the exercise rooms at the Rec Center, more pleasant to be in [20]. In fact, studies have shown that certain factors, such as choice of color in an interior design, that may seem subjective at first glance can actually be broken down into psychological categories [20]. For example, the use of black in interior design has been proven to promote psychological effects of “Dark, serious, severe, uneasy, stressful”, while the use of white has been proven to promote psychological effects of “Pure, simplicity, fresh cold” [20]. In relation to our problem statement, a data-based discovery such as this leads to the conclusion that an overcrowded space such as the Rec Center exercise rooms might benefit from incorporating as much white into their interior design as possible, while minimizing the use of a “stressful” color such as black.

Another approach that could aid in making an environment suffer less from the effects of overcrowding is one of minimizing the presence of indoor air pollutants. In a crowded environment, risk of exposure to indoor air pollutants increases significantly beyond national limit values [5]. Beyond this being the case in general application, gymnasiums suffer from this phenomena even further due to more drastic “changes in the respiratory parameters caused by the physical activity” [5]. The most effective form of eliminating this risk would typically be to ensure sufficient ventilation through a proper HVAC system [5]. Relating this to the focus of our project, if insufficient ventilation exists in the overcrowded exercise rooms at the Rec Center, implementation of an improved air conditioning system could drastically improve the overall experience of users through the minimization of indoor air pollutants.

Indoor facilities give the luxury to not have to withstand unpredictable weather conditions. In Japan, indoor exercise facilities came first due to a rise of pollution in the air where the demand for space is critical. With that, the article “The Discipline of Space in a Japanese Fitness Club” explains key factors that help reduce the effects of over crowdedness. One of the philosophies the Japanese club carries is that “looking fit is as important as feeling fit” explaining why glass and mirrors should be a key component of the architectural design [10]. The effect of this philosophy is that it invites people to self-monitor and scrutinize others, which will, in effect, distract the feel of overcrowding. In addition, traditional Japanese shoji screens have been used to extend small spaces and add flexibility to the floor plans [10]. This idea of adding screens can be especially helpful with regards to adding flexibility in equipment placement around the inconveniently placed structural pillars.

The final approach that was researched in advance of this project’s execution was the path of designing optimal exercise room equipment layouts, a promising approach that has the potential to drastically improve overall user experience within the exercise rooms at the Rec Center. The design of an optimal layout is an issue that spans a wide variety of applications, in addition to our project’s case of equipment layout. Regardless of what specific type is being analyzed, a consistent factor in any creation of an optimal layout is some form of quantitative measurement; a way in which the “after” model can be shown as superior to the “before” model [9]. Aside from that, there is a significant amount of options in terms of layout methodology. In addition, a key
factor to note about this form of approach is that implementation does not necessarily require financial investment. Rather, it is simply a matter of re-organizing equipment that is already owned in most cases.

**Selected approach to the issue of overcrowding**

While each of the many forms of approach analyzed above have the potential to greatly reduce the effects of overcrowding within the Rec Center’s exercise rooms, one of the forms of approach seemed to stand above the rest as the most practical option. In terms of implementation, most of the possible approaches had a high probability of requiring large investments of time, effort, and money. A form of implementation that is small and convenient in nature is most desirable for this project, given its time constraints and scope capacity. For this reason, our decision was to remain focused on what seems to be the aspect of the exercise rooms that is easiest to alter, but has just as much potential for benefit: the equipment layout designs.

The first step to meet the objective of reducing the effects of overcrowding is defining the problem and identifying the areas that are highly impacted. Now, to continue this approach in a data-driven manner we decided to conduct an online survey through the surveymonkey website. Research on customer satisfaction surveying led us to creating an effective rating scale. This includes having two types of score: the item evaluation score and a measure of item importance level [16]. We will assign values from one to five to the importance measurement score from strongly disagree to strongly agree, respectively. In addition, we can weigh each question according to the degree of influence in reducing the feel of overcrowding. Another aspect of our survey is including descriptive variables at the start of the survey. These include gender identification, type of member, frequency, time of day and others, which allows us to identify demand relationships that will, in turn, help find negatively impacted areas.

Another methodology regarding the design process of the exercise rooms is an integrated approach by logistic and re-layout program. This fundamental approach considers both of following factors: the flow of materials and the relationship amongst activities [8]. In our case, the routine carried out by each individual member will denote the flow of material and the relationship amongst activities ought to represent the type of exercise with regards to muscle group. In order to obtain this information, we will be making spaghetti diagrams as well as noting the muscle group the subject is exercising. In the end, with the objective to minimize flow of students, these tools will help shape the first draft of the design layout.

The inventory database is another important aspect of our project such that it will expedite our design process and become an effective tool to filter through equipment for any future layout re-designs. A case study at Greta’s Gym exposes that as gym popularity increases, the implementation of an interactive database is highly encouraged [3]. The study followed a series of steps including data gathering, conceptual data model, relational tables, and lastly the physical database design [3]. In addition, part of the database implementation shall include a training manual that will instruct staff how to use the model as well as explain the logic behind the developed queries [3]. Another potential feature in relation to the equipment database is a maintenance support system. An article regarding decision support systems of railway preservation explains that the main three tasks of infrastructure maintenance and rehabilitation are symptom observation, condition diagnosis, and treatment identification [11]. Completing such tasks shall require identifying the root causes for equipment deterioration, define equipment lifetime and list potential solutions to incorporate in the database.
The database will also include a property for demand of each equipment type so that we can make a data-driven approach to the design layout. This will inquire the technique of work sampling since there is no existing data on equipment demand. A study on the duties of an engineering professor outlines their approach of work sampling techniques. The main steps in developing the framework of this study are as follows [2]:

1. Identify the primary tasks or activities for the study.
2. Estimate the proportion of time of the activity or interest to the total time.
3. State the desired accuracy in the study results.
4. Determine the specific times when the study needs to be performed. Random number generators or tables are used to determine these random intervals.

By following these steps, we will have quantitative inputs to analyze the demand for the different types of equipment. The results we get will surely influence the feel for overcrowding since we will include more of the demanded machines in the re-design layout.

**Research of possible methodologies for chosen approach**

Once our focused approach was chosen out of the multitude of potential areas analyzed in the previous section, the next step in preparation for the completion of this project was to solidify the methodology that will serve as the foundation for execution. There are many ways in which our team could go about designing the optimal equipment layouts for the exercise rooms, so it’s critical to research and compare all of the plausible options. While the concept of designing a new equipment layout may seem limiting in some regards, there is actually a reasonable amount of qualities that can be considered in the process.

One example of a possibly non-intuitive part of the approach is the incorporation of the sanitation side of exercise rooms. Proper sanitation practices become even more essential in a fitness environment that regularly experiences overcrowding [17]. Despite this being the case, studies have shown that there is often a drastic divergence when it comes to gym users: those who sanitize equipment after each use and those who never sanitize [17]. This problem of demotivated users could potentially be resolved in part by ensuring a thorough distribution of sanitation equipment throughout each exercise room, so that there is as minimal reason to avoid sanitation as possible.

In addition, a main challenge that faculty staff have to deal with is the variable use of equipment, whether it be moving benches, free weights, or workout routines. With that, it is important to be able to identify exercise trends in the Cal Poly community. Ideally, this will allow predictions of workout routines, which will in turn, help determine where to place equipment in order to minimize flow of people.

Building off of the subject of equipment use variability, it is also an important methodology to always consider equipment location options. One interesting approach that often isn’t considered is the re-location of certain gym equipment to outdoor areas owned by the facility. Not only would such implementations increase usable space in the exercise rooms at the Rec Center, for example, but studies have also shown that outdoor gym equipment use has the potential of improving social interaction among equipment users [18]. With space being a relative constant
constraint in our project’s approach, considering options such as outdoor space usage is an interesting and worthwhile opportunity.

The need for space is a critical problem amongst many organizations. A study regarding public transportation systems defines the overcrowding based on various factors such as physical density, space limitations and different psychological aspects that influence a public transport use [19]. The issues associated with a crowded bus are emotional distress and creates a negative psychological impact, which, in turn, becomes impacts costs as the service becomes less attractive [19]. Another interesting approach of their survey was including pictures with levels of over crowdedness to which a weight was assigned to each level. Furthermore, the study used a density metric to compare the effects of overcrowding in other bus systems. With that, defining a metric for comfortable space for an individual through ergonomic studies can be useful input for the design layout process.

The Cal Poly Rec Center has many amenities to offer and it would be beneficial for our data-driven approach to investigate the frequency at which members return for the same amenity. However, due to time constraints, lack of documentation, and privacy issues, an in-depth study is an unfeasible task for our project. On the other hand, a study in Brazil investigated 367 students in order to predict the number of students in the control of time [1]. Through the process of using conditional probabilities to assemble a transitional matrix, the study indicated that around “53% of the people that subscribed to the gym for the practice of Bodybuilding, stayed in it after the first transition, while the Cyclism, the Water Aerobics, the Swimming and the Located Gymnastics received, respectively, 12.00%, 10.00%, 5.00% and 16.00% of the students’ of that modality” [1]. What this reassures us that the increasing demand for the exercise rooms is a definite one, since we can expect first time users of the exercise rooms return, unlike first time users of other amenities.

In addition, knowing the process of forming a habit can be helpful in predicting how many established active members are using the certain amenities. A study investigated exercise habit formation through a dual process approach and concluded that it takes about 6 weeks to establish a habit with 48% of contestants achieving habit formation [14]. This puts emphasis on intimidation factors, which are important to consider when trying to distribute people evenly throughout different amenities. For example, it would be beneficial to have free swimming lessons in order to reduce the intimidation factor and increase the use of a less demanded amenity.

Another important factor to address is determining whether overall customer satisfaction is increased through standardized or customized methodologies. In our case, the standardized methodology would infer a layout that fits the needs of the majority of the Cal Poly population. On the other hand, the customized methodology would conclude a layout that allows the active community to determine the design layout based on their own needs. A study addressing the effects of standardization and customization on service quality and customer satisfaction shows that “standardization has a higher impact on service quality” [13]. The article explains that standardization is used to help management control, minimize mistakes and increase reliability [13]. In addition, it is interesting to note that those people who go to the gym with a goal focusing on pleasure tend to like customization more, whereas those with a goal focusing on functionality are more likely to prefer standardization [13].
When it comes to general philosophies behind the methodology of design, certain subjects are worthy of consideration as well. A subject matter that may be particularly relevant is one of gender, and how such a factor plays a role in overall user experience. Studies in the past have been able to conclude a drastic difference in likelihood to lift weights publicly, between men and women, despite the equally proven health benefits for both genders [12]. In addition, this divergence is particularly one of weights specifically, rather than the gym as a whole. For example, an action such as doing aerobic exercises is considered less intimidating than lifting weights to women [12]. In the same study, three primary causes for this diminished desire to lift weights were also found [12]:

1. fear of evaluation by others
2. fear of comparison to others
3. fear of inadequate experience

To tie this into the scope of our approach, these findings would be beneficial to keep in mind when it comes to the philosophical motivation behind the equipment layout designs. It’s hard to pinpoint the application in advance of the design process, but since our main goal is to improve overall user experience while in the exercise rooms, this area has a lot of potential for boosting the impact of our design, especially when it is known that women currently outnumber men on average in terms of fitness club memberships [15]. Creating equipment layout designs that properly appeal to both genders equally is a current trend that is constantly growing in the fitness industry, and as such it will likely be wise for us to try to implement this idea just as much [15].

On a final note regarding the possible methodologies for our approach, the most critical subject to base our design on is, most likely, ergonomics. The obvious application revolves around making sure that every part of our design is either in line with, or beneficial to, the overall ergonomic effect of the exercise room. However, it is equally important that any ergonomically-based decisions are executed in as professional and conservative of a manner as possible. When it comes to ergonomics, the consequences of making an assumption or using inaccurate data is highly severe, due to the fact that the victim in such a situation is people’s physical health [7]. There are many guidelines that should be followed when it comes to an ergonomic approach to a problem, in order to minimize the risks of making a mistake that leads to considerable consequences. As a result, our equipment layout designs for the exercise rooms will likely benefit from a heavy emphasis on conservativeness when it comes to ergonomic decision-making.

Selected methodologies for chosen approach
In contrast to the section in this report that focused on narrowing down to a single selected approach, the process of selecting concepts that contribute the methodology for our approach is more forgiving because multiple concepts can be incorporated. For this reason, our decision was not to narrow down our researched options for methodology at all, but rather plan to incorporate all of them as much as possible. Beyond that, the only final thing to note in terms of planning for our design, is the issue of quantification. In any project involved in process improvement, it is critical to have a means of quantifying the “before” phase as well as the “after” phase of one’s implementation. In this regard, our project’s efforts hit somewhat of an obstacle, due to the fact that overall user experience within the Rec Center’s exercise rooms is a highly subjective measurement that is based off of an immensely large number of qualities. One possible option is
to gather data on overall customer satisfaction before any changes are made, make changes, and then gather data again on overall customer satisfaction to hopefully see an increase in average rating. However, given the timeline of our project, and the fact that we are not the owners of the Rec Center, it can’t be guaranteed that we will be given the chance to implement our equipment layout designs at all. As a result, measurement of a quality that appears to be the most impactful, such as total “usable” space, may be necessary. From this angle, two main forms of approach are then possible: a quadratic formulation approach and a graphic formulation approach [9]. In order to quantify total “usable” space, equations with declared variables could be created in order to calculate a number that represents the total “usable” space before and after implementation. In contrast, the exercise rooms could be graphically represented and analyzed in terms of qualities such as equipment adjacency, location of “usable” space areas, and other factors that get lost in a quadratic process. Both methods have different benefits and drawbacks, and the execution of the design process will surely come with more insight on which option is more suitable, but it is our decision to keep both available methods in mind for the time being.

**Design**

To fully understand the dynamics of the Cal Poly Rec Center facility, we will be describing the core philosophy as well as constraints that have shaped the current design layout of the exercise rooms. In addition, we will discuss the process involved with implementing a new database system that will allow management to be able to filter through inventory. Lastly, we will explain the design process of optimal equipment layouts for the three exercise rooms once we have discussed strategies for completing all the preliminary objectives.

The Cal Poly Rec Center is a facility that is unique in its architectural structure giving it the ability of having a diverse set of amenities that are free and available to students. Some of these amenities include the basketball, racquetball, swimming, exercise rooms, and studio rooms where various classes are offered such as Yoga and Spinning training sessions. These amenities help distribute people throughout the facility, which in turn helps minimize the effects of overcrowding. However, management has tried to find the balance between demand and the cost associated with each class. With that, classes provided in the studio rooms are usually scheduled during peak hours. Throughout the report we will be referring to peak hours to be 10:00A.M. to 12:00P.M. and 4:00P.M. to 6:00P.M. Monday through Friday.

At the beginning of our project, we performed a survey among students at Cal Poly in order to potentially find bottlenecks that amplify the effect of overcrowding. The survey was performed through the website surveymonkey and included descriptive questions such as type of member, weekly facility usage, general thoughts on the issue of overcrowding at the Rec Center. In addition, we included topical questions regarding the presence, personal opinion and gravity of the problem. The topical questions will determine the areas in which people are experiencing negative effects. For distribution, we utilized social media pages that were exclusive to students at Cal Poly and used connections with Professors to have the survey be emailed to classes and departments. In total, the survey was completed in full by 201 participants. Given the large amount of data gathered, we believe significant conclusions can be derived from the survey’s results. As far as insightful results go regarding the survey, there are multiple useful takeaways from participants’ feedback. Since these takeaways largely funnel into specific design approaches, however, such results will be referenced in the relevant areas below, where the results are used in relation to decisions in design, rather than summarized here.
Identification of current hard constraints
One influential factor in the design layout of the exercise rooms is the physical constraints. These constraints include qualities such as power supply outlet locations, structural pillars, and available floor space dimensions. The power supply locations heavily limit the placement options of most cardio machines, since they have to be within a tight range of the available outlets. In addition, structural pillars create physical spaces of unavailability randomly throughout each exercise rooms, making a linear equipment layout design approach a hindered process. The floor space dimensions of each exercise room itself also create a hard constraint that limits design. This is because each exercise room is far from rectangular in nature, and instead consists of dimensions that change and arc at random lengths and angles. This forces linear rows of equipment to end and begin at inconsistent lengths, and creates a lot of opportunity for space to be wasted. Regardless of the other aspects of our approach for design, these physical constraints of each exercise room create a concrete foundation that everything else must be based upon.

Identification of current soft constraints
One of the first soft constraints that we discovered in our project was the general design philosophies held by the staff in charge of equipment layout at the Rec Center. Before detailing these design philosophies in full, it is important to note that these constraints, in application for our project, are actually to be treated as hard constraints. This is due to the fact that in communication with the Rec Center staff, we were directly informed that they do not intend to waver on these design philosophies that they currently hold to. The reason, however, why these constraints are being detailed here as ‘soft’, is simply because, theoretically, they are a completely changeable constraint in terms of design. First, the Rec Center assumes that many students have not had a real gym experience before attending this university, so it’s philosophy aims at minimizing intimidation factors that can potentially drive new members away. For example, when entering any of the three exercise rooms, students will first encounter isolation machines and gradually move towards heavy weight lifting equipment as they get deeper into the exercise room. Another part of the core philosophy is designing each room with similar equipment so that students can get the same workout regardless of which exercise room they are in. The purpose of this characteristic of the layout is to accommodate most student’s workout routines whenever an exercise room is closed for maintenance or re-design. Conveniently, these implementations are mostly done over the summer when overall demand for the facility significantly decreases.

Since the Rec Center opened, gym staff has also developed a set of soft constraints with regards to safety and aesthetics. Originally, safety assumptions were made by experienced staff members in determining a general pathway width, while complying with ADA accessibility requirements of a minimum of 30 by 48 inches of free space next to equipment groups and a minimum of 36 inches for aisles, as shown in Figure 3 [21]. Another characteristic of the layout in terms of aesthetics is the ability to look down a path or walk-way and being able to see through to the other side of the room. This characteristic intends to make it easy for students to quickly locate an available machine. On the other hand, while increasing the aesthetically pleasing factor, it limits our re-design layout such that we can’t place tall workout equipment in the middle of the exercise room for spatial convenience.
Work sampling data collection

The Rec Center has a variety of amenities that contributes to its increasing popularity. However, through our initial survey we were able to conclude that high usage in the exercise rooms, which drove us to investigate the root cause for the effects of overcrowding within each exercise room. With that, we executed a work sampling study on each of the three exercise rooms in order to calculate equipment utilization percentages. This data will then be used to recommend equipment layout alternatives that involve the removal of low usage equipment and replacement of high usage equipment. The goal here is to create a balanced environment in order to mitigate the effects of overcrowding. In the following section, we will explain the standard procedures as well as any constraints in conducting the work sampling study.

The scope of our work sampling study aimed strictly at three categories: isolation machines, cardio equipment, and compound equipment. The isolation machines are typically located at the entrance of each exercise room to create a welcoming effect when transitioning into heavy lifting equipment areas or active cardio zones. In terms of the on-site data collection, we set a standard route for recording equipment usage in order to minimize the time and variability in each trial. As far as recording methods, we received approval from the Rec Center staff to begin our work sampling study using Google Spreadsheets on our phones. Furthermore, each equipment category was subdivided into groups which symbolized particular rows of equipment within that category. In addition, part of the standardization included instructions on the spreadsheet explaining whether recording should be done front-to-back or back-to-front for each particular group as shown in below in Figure 4. The other exercise rooms are available in the Appendix as Figures 5 and 6.

- Group 1- Isolation (left side; front-to-back)
- Group 2 - Isolation (middle; back-to-front)
Initially, our plan was to conduct 50 trials randomly during peak hours. However, due to the lifespan of this project, we were unable to conduct all trials within the time limitations presented in the original plan. Therefore, some samples were conducted in series, meaning that data collection was continuous such that once a trial was completed, we immediately started another one. However, with such a large area to cover within each trial our data integrity remained healthy. By the end of the work sampling study, we achieved to collect a total of 50 samples on all equipment within scope in the three exercise rooms using a binary scale, where a one represents that the equipment currently in use and a zero means the equipment is available.

Data Analysis
Once the work sampling study was completed, we set an objective to develop a graph where the user can easily depict between overutilized and underutilized equipment. First, we calculated the average percent utilization for all equipment types by grouping any duplicates, such as “flat bench press” or “squat rack” as shown in Figure 7 below.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Compound Equipment</th>
<th>Avg % Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>shoulder press</td>
<td>26.00%</td>
</tr>
<tr>
<td>1</td>
<td>smith machine</td>
<td>48.00%</td>
</tr>
<tr>
<td>1</td>
<td>decline bench press</td>
<td>52.00%</td>
</tr>
<tr>
<td>1</td>
<td>incline bench press</td>
<td>54.00%</td>
</tr>
<tr>
<td>2</td>
<td>squat rack</td>
<td>81.00%</td>
</tr>
<tr>
<td>3</td>
<td>flat bench</td>
<td>81.33%</td>
</tr>
</tbody>
</table>
This information will be useful when determining which equipment to buy when using the conservative design approach explained in a later section. Once duplicates were grouped, we used a histogram to compare the utilization all equipment sampled within each exercise room. For example, Figure 8 shows the equipment usage for the second floor big exercise room. From this histogram, we can easily see that the “flat bench press” is utilized the most, whereas the “cybex arc trainer” can be considered underutilized. The histograms for the other exercise rooms are shown in the Appendix as Figure 9 and Figure 10.

Now, given that we cannot address the problem statement directly as to expand the building itself, we addressed the fact that adding more equipment to the existing layout would actually contribute to the effects of overcrowding. With that, we proposed two alternative approaches of selling and purchasing equipment that will shape the final design layouts.

Creation of recommended equipment layouts
With all hard and soft constraints identified in full, as well as the completed data analysis resulting from the work sampling study, the creation of recommended equipment layout alternatives was the next step. Regarding methodology, the creation of these layouts were to be executed through the use of Icovia Software Planner, a URL-based layout creation software that the Rec Center is currently beginning to utilize alongside our project. We chose this means of layout creation due to the preference of the Rec Center, as navigating our designs in the software that they are familiar with is a convenient process. With the means of creation selected, we then created a total of nine layouts within the Icovia software; three layouts for each exercise room. The layouts created for each exercise room are as follows and will be described in detail later on:

- Current layout
• Conservative alternative layout
• Aggressive alternative layout

Each layout is accurately dimensioned, spatially, through the utilization of The Rec Center’s construction blueprints. Each currently existing piece of equipment within each exercise room is also indicated with an accurate visual symbol, when possible, and its location within the respective exercise room is closely estimated. For each alternative layout, the removed and added equipment lists are indicated visually and in writing. In addition, any added equipment is shown within the layout itself and given a location that satisfies any soft or hard constraints of the exercise room, when applicable.

In the beginning of this process, it was critical to not put all of our eggs in one basket in terms of design. We are aware of two distinct and powerful stakeholders for the Rec Center: its staff and its members. While some of their desires for an optimal exercise room layout overlap, many desires differ significantly. For example, the Rec Center staff heavily desires changes that are rather minimal in impact, due to the fact that they run the risk of wasting a lot of time and money if the changes don’t end up being worthwhile. However, it is clear from our survey analysis that students are much more comfortable implementing aggressive changes, so long as they are involved in the decisions of what is changed. Therefore, we decided to design two equipment layout alternatives for each of the three exercise rooms, in the hope that their distinct rules of design, described in the following section, will be able to offer a beneficial comparison. It is also important to note that in our creation of these layout designs, there are many limiting factors that result from the issue of subjectivity. From our work sampling study, we created a tier list of equipment usage within each exercise room, but to what extent equipment replacement is followed, and what rules are applied to filter through the tier list, is less of a data-driven decision and moreso one of preference. As a result, we tried to capture what we think are two distinct sides of preference when it comes to layout design.

**Conservative Design**

The conservative design, in nature, is intended to cater towards the stakeholder that wants the less drastic alternative layout, with as few polarizing decisions made as possible. This design attempts to challenge the Rec Center staff’s soft constraints for each exercise room as little as possible, while suggesting changes that aim to only add value to the overall layout. The rules created for this layout design, in regards to the equipment replacement aspect of the design, are detailed below:

• Beginning at the least used piece of equipment, sell the 5 least used pieces of equipment
• Beginning at the most used piece of equipment, Purchase duplicates of the 5 most used pieces of equipment
• Pieces of equipment that are a “one-of” are not considered for selling
• Only the first appearance of a piece of equipment that already has duplicates is considered for purchase
In addition to the major set of rules shown above, it is critical to consider the differences of equipment size in the process of equipment replacement. As a result, we created a size factor system that grants each piece of equipment a roughly estimated size factor quantity. With this implemented, the final rule followed in each conservative design is as noted below:

- Stop purchasing equipment once the purchased equipment cumulative size factor quantity equals the sold equipment cumulative size factor quantity
- Stop purchasing equipment if the next purchase would cause the purchased equipment cumulative size factor quantity to be greater than the sold equipment cumulative size factor quantity

As mentioned previously in this section, it is important to acknowledge areas of limitation within our design process. When it comes to our created set of rules for the conservative layout designs, the benefit of low-risk equipment replacement comes at the cost of reduced improvement on the current unbalanced nature of equipment usage. This reduced impact comes from that fact that, in application, a large amount of each exercise room’s equipment usage tier list becomes unconsiderable due to the design’s set of rules. What this leads to is the selling of equipment that isn’t necessarily low usage, as well as the purchasing of equipment that isn’t necessarily high usage. The major purpose of these alternative layouts is to minimize the unbalanced nature of equipment usage. As such, this alternative design is relatively minimal in terms of accomplishing that goal. The end result is still a more balanced equipment layout, but it simply sacrifices some influence towards this goal in order to remain low risk.

With this established set of rules followed thoroughly, in addition to the current hard and soft constraints for our design, a conservative alternative layout for each of the three exercise rooms in the Rec Center was created. The conservative alternative layout for the second floor big exercise room is shown below in Figure 11. The first floor and second floor small exercise room conservative designs are displayed in the Appendix as Figure 12 and Figure 13, respectively.

![[Figure 11] 2nd Floor BIG - Conservative Design](image)

**Aggressive Design**

The aggressive design stands in rather sharp contrast to its counterpart, the conservative design. It attempts to cater more heavily towards the students of Cal Poly, in that it prioritizes the minimization of equipment usage imbalance over everything else. As such, the soft constraints imposed by the Rec Center staff for each exercise room are not strictly followed for this design.
This form of layout change yields minimal limitations by design, but its most notable concern lies in the likely polarity of its popularity. If the high risk equipment replacements do not directly benefit a specific student, for example, they are very likely to find the changes unappealing overall. This could very well lead to two major bodies of opinion on these alternative layouts: one in which students heavily prefer this alternative layouts, and one in which students heavily dislike the alternative layouts. The rules created for this layout design, in regards to the equipment replacement aspect of the design, are detailed below:

- Beginning at the least used piece of equipment, sell the 10 least used pieces of equipment
- Beginning at the most used piece of equipment, Purchase duplicates of the 10 most used pieces of equipment

Since this is the aggressive alternative design, there are no notable exceptions to the rules shown above. This allows for multiple duplicates of a single piece of equipment to be purchased, if more than one of that piece of equipment is within the top 10 most used pieces of equipment. In addition, this allows for “one-of” pieces of equipment to be sold, leading to that piece of equipment now being completely unavailable within the exercise room, or potentially the entire Rec Center, if the same piece of equipment is low enough on each room’s tier list.

In addition, the issue of equipment size is still considered in this alternative design, just as it is in the conservative design. The rules are the same as before, and are listed below:

- Stop purchasing equipment once the purchased equipment cumulative size factor quantity equals the sold equipment cumulative size factor quantity
- Stop purchasing equipment if the next purchase would cause the purchased equipment cumulative size factor quantity to be greater than the sold equipment cumulative size factor quantity

As mentioned before, we expect this alternative design’s main concern to be one of polarizing feedback. It is a high-risk, high reward approach to the issue of equipment usage imbalance, because it aims to simply follow a data-driven approach of what equipment is on the most extreme ends of the work sampling results. For students who do not use the equipment that is to be added, there is a high probability that they will only see a decrease in satisfaction if this design were to be implemented. This is due to the likely chance that one or more of the removed pieces of equipment is something that they use, at least, some of the time. In contrast, for students who do use the equipment that is to be added, they will likely see extreme value in the new layout because their experience of equipment unavailability would decrease drastically. Despite this polarizing response being probable, it is still a worthwhile alternative layout design to consider, due to its heavy data-driven nature.

With this established set of rules followed thoroughly, in addition to the current hard and soft constraints for our design, an aggressive alternative layout for each of the three exercise rooms in the Rec Center was created. The aggressive alternative layout for the second floor big exercise room is shown below in Figure 14. The first floor and second floor small exercise room aggressive designs are displayed in the appendix as Figure 15 and Figure 16, respectively.
Creation of equipment inventory database

In addition to the design of alternative exercise room layouts, we created an equipment inventory database for the Rec Center staff to utilize. The purpose of this database is to minimize chances for errors to occur in the recording of their equipment inventory, as well as expedite any future processes that include the referencing and editing of equipment inventory. With the Rec Center staff’s current inventory being recorded on excel, we concluded that a database created in Access was an appropriate alternative. The major features of the database are as follows as shown in Figure 17:

- Ability to filter by major equipment categorizations
- Ability to add, edit, and delete inventory
- on-the-fly equipment search criteria
- Ability to view sum quantities of choice equipment categories
- Full representation of current inventory list of categories
The list of features to be included in the database were derived, as much as possible, from the needs of the Rec Center staff that were made known to us. Another major design approach to this database was to keep it as simple and intuitive as possible, since the Rec Center staff is not extremely accustomed to the use of Access. As a result of both of these factors, the quantity and depth of the database’s features were intentionally kept as simple and minimal as possible, while still meeting all of the customer’s needs thoroughly. With these features of the database closely abided by and tested, the database was created. In addition, the Rec Center’s current inventory list of their equipment was transferred into the database, so that no time or effort needs to initially be spent on the Rec Center staff’s end in order to transfer between the two databases.

On a final note, we anticipate the learning curve for the Rec Center staff in regards to use of our designed database to be relatively fast, due to its simple and intuitive nature. Nonetheless, in our deliverance of the database, we plan to walk them through the general uses of the database to ensure that no potential confusion or difficulty arises on their end. Creating a written manual for the usage of the database was considered, but ultimately concluded to be unnecessary.

Methodology

The testing methodology of our alternative designs is a virtual one, in that no physical implementation was feasible within the time limitations due to the project lifespan and longevity of administration’s approval process. Now, having a current, conservative, and aggressive design layouts for each exercise room, we began shaping our second survey. The first three pages of the survey were dedicated to the exercise rooms, each page indicating a certain exercise room with the current, conservative, and aggressive layouts displayed. With each of these alternatives presented, we decided to record two types of responses:

- 1 to 5 Star Ratings for each design presented
- Most appealing design for each exercise room
We believe this is testing methodology is valuable since responses will be directly from our primary stakeholders, the Cal Poly student population. With these two types of responses, we aim to see whether there is a statistical difference between the choice of most appealing design and to identify the potential impact of implementation of the alternative designs offered. These findings will be presented shortly in the following section. Now, with the distribution of votes within the 5 star rating scale for each design presented, further analysis of this data will allow us to confirm our predictions of the type of audience each design is more likely to cater towards. In addition, we will determine whether there is a statistical difference in votes of most appealing designs within each exercise room. To do this, we will be using a two proportion hypothesis test to evaluate whether there is a statistical difference between the conservative and aggressive designs. The results for the 2nd Floor BIG exercise room for the aggressive and conservative designs are presented below in Figure 18.

![Figure 18] 2nd Floor BIG - Hypothesis Test Results

From the high p-value obtained (p > 0.05) in comparing the aggressive and conservative designs for the 2nd floor big exercise room, we can conclude that there is no statistical difference between the two. Similarly, there was no statistical difference between the conservative and aggressive designs for the 1st floor exercise room as shown in Figure 19 in the Appendix. On the other hand, the 2nd floor small exercise room gave more conclusive results, in that we concluded a statistical difference between the two designs, test shown in Figure 20 in Appendix.

Another relevant factor for the implementation of either new alternative designs is the cost-benefit analysis. With that, we included a fourth page to our survey to include theoretical analysis of the cost of implementation, as well as a short-term action option of re-allocation of resources. The theoretical scenario was derived from each alternative design’s purchase requirements divided by the total number of Cal Poly students in three academic quarters. Cost estimates and calculations for the conservative and aggressive designs are shown in Figure 21 and Figure 22, respectively.

- Conservative Design - $0.50 increase in ASI fees
- Aggressive Design - $1.00 increase in ASI fees

Given these costs, a survey question was proposed to determine whether such increase in ASI fees deemed fair given their respective impact upon implementation. With these results outlined in the following section, we discovered that the student population is willing to invest for change, given the fair costs, in response to the overcrowding issue at the Rec Center. However, a challenge faced when raising the student fees is the fact that rarely do quarterly fees decrease, so we cannot ensure students that fees will decrease once the breakeven point is reached. Now, given that a real referendum is far from our scope time limitations, we proposed a hypothetical one where students had to choose between either alternative or to keep fees as they were before.

Lastly, we incorporated another way to fund the alternative proposed designs, which was through the redistribution of the Rec Center’s yearly operational budget. Through this question, we will obtain student’s willingness to reduce budget allocation of other program areas of the Rec Center.
in order to reduce the effects of overcrowding in the most impacted areas, the exercise rooms. Results will be displayed and analyzed in the following section.

Results

The results from the methodology portion of our project were extremely helpful in understanding the general impression of Cal Poly’s student body, regarding our layout designs. The first noteworthy result from student feedback is that, on average, 69% of students voted in favor of an alternative layout for an exercise room over the current layout. The results of this portion of the survey is shown in more detail below in Table 1:

<table>
<thead>
<tr>
<th>Layout</th>
<th>1st Floor (%)</th>
<th>2nd Floor BIG (%)</th>
<th>2nd Floor SMALL (%)</th>
<th>Overall (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>35.71</td>
<td>33.33</td>
<td>23.08</td>
<td>30.71</td>
</tr>
<tr>
<td>Conservative</td>
<td>39.46</td>
<td>27.78</td>
<td>25.64</td>
<td>27.63</td>
</tr>
<tr>
<td>Aggressive</td>
<td>34.82</td>
<td>38.89</td>
<td>51.28</td>
<td>41.66</td>
</tr>
</tbody>
</table>

[Table 1] Layout Vote Distribution for each Exercise Room

This strongly indicates that students are very interested in the prospect of changing the exercise room layouts, which is a notable conclusion in and of itself. If analyzed independently, however, the selection rates of each alternative layout, individually, are not statistically significant in terms of a higher selection rate than the current layout. The only case where an alternative layout was selected significantly more than the current layout was the aggressive alternative layout for the smaller 2nd floor exercise room.

![Test and CI for Two Proportions: Current, Aggressive](image)

[Figure 23] 2nd Floor SMALL 2 Proportion Hypothesis Test - Current vs Aggressive Layout

In this scenario, as shown in Figure 23, hypothesis testing of two proportions concluded that the aggressive layout’s selection rate can be concluded to be higher than the current layout’s selection rate, overall. In addition to selection rates, the average 5-star ratings for each exercise room layout design also yielded notable results. The average 5-star ratings and standard deviations among exercise rooms for each layout category is as follows:
<table>
<thead>
<tr>
<th>Layout</th>
<th>Average Rating</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>3.42</td>
<td>1.05</td>
</tr>
<tr>
<td>Conservative</td>
<td>3.40</td>
<td>1.03</td>
</tr>
<tr>
<td>Aggressive</td>
<td>3.24</td>
<td>1.45</td>
</tr>
</tbody>
</table>

[Table 2] Average Rating and Std. Deviation for Each Design

With this form of analysis, it can be safely concluded that neither the conservative nor the aggressive layout alternatives were met with overwhelmingly positive student feedback. This is because both of their average ratings fell below the average rating for the current layout, overall. However, the average ratings for each alternative layout were only lower by a small degree, which offers hope that the issues with each alternative layout design are rather small and solvable. In addition, it is noteworthy that the aggressive layout designs resulted in the highest standard deviation. While it can’t be concluded with certainty what the cause for this is, it is likely that this high level of deviation is due to the aggressive layout’s high-risk, high-reward nature. In other words, for the students who do not regularly use the equipment to be added, they see no value provided to them, at the cost of losing certain equipment. On the other hand, for the students who do regularly use the equipment to be added, they see high value provided to them, at the lesser cost of losing certain equipment. This could have very well lead to the result of highest number of 1-star or a 5-star ratings for the aggressive design (in green) as shown in Figure 24, but as said before, this is merely a potential explanation.

The portion of the survey that addressed the business case aspect of the layout designs resulted in positive student feedback, overall. The question of theoretical student funding through a referendum, as mentioned previously, and shown in Figure 25, resulted in 79.49% of students stating that the conservatively estimated quarterly cost per student seems either low or appropriate, given the expected impact of such alternative layouts.
In the follow up question regarding what layout they would select, if such implementations were offered in a referendum is shown in Figure 26. Among the three options, the aggressive alternative layout was selected the most by students, at a selection rate of 39.74%. If the two alternative layout selection rates are combined, a total of 70.51% of students selected an alternative layout in the theoretical referendum over keeping the current layout.

As noted in the previous section, it was important to include more than one theoretical means of implementation. As such, with the concept of the Rec Center simply redistributing some of its yearly operational funds to implementing these changes, student feedback was positive as well. As shown in Figure 27, 53.85% of students agreed that this form of implementation would be a good idea, given that the means of redistribution are appropriate.
Conclusion

The results of our second survey, which provided us with student feedback on our exercise room equipment layout alternative designs, were certainly not ideal. While the specific issues with each alternative design structure can’t be determined for certain at the moment, it is clear that students, collectively, do not consider either of the alternative designs to be significantly better than the current layout for each exercise room. However, it is highly possible that if we only offered the choice of 1 alternative layout, rather than results of preference being dispersed between two alternative layouts, the alternative layout may have received more significant preference over the current layout. In addition to the alternative layouts still receiving higher ratings and more preferences in some cases, we consider it reasonable to still conclude recommended alternative layouts for each exercise room to the Rec Center staff. Our recommended alternative layouts are as follows:

- 1st floor exercise room - Conservative Alternative Layout
- 2nd floor larger exercise room - Conservative Alternative Layout
- 2nd floor smaller exercise room - Aggressive Alternative Layout

Regarding each of the exercise rooms, the conservative alternative is chosen as the default recommendation for a significant reason, despite it not yielding extremely higher selection rates than the current layout. This is due to the fact that while the selection rates for each of the three layouts were relatively close in quantity, it is important to note that the students who voted for a
new layout over the current layout were dispersed into two categories: the aggressive and conservative alternatives. This means that if, in hindsight, we had only offered students the choice between the current layout and one alternative design, it is likely that the selection rate would have been much higher for that one singular alternative design. In order to determine which alternative should take priority of this conclusion, though, it is safe to assume that most students who prefer the aggressive layout designs likely also prefer the conservative layout designs, at least in contrast to the current layout. This can’t safely be concluded in the other way, where many people who prefer the conservative layout have a good chance of considering the aggressive layouts too extreme. As a result, despite our survey results not being as conclusive as desired, the conservative layout design for each exercise room is recommended as the default choice when the survey results aren’t statistically significant. This led to our recommendations for both the 1st floor exercise room and the 2nd floor larger exercise room being the conservative layout. However, our recommendation for the 2nd floor smaller exercise room is the aggressive layout, due to the fact that it yielded a much higher selection rate than both the current layout and the conservative alternative.

In regards to the financial aspect of our project’s recommended implementations, student feedback regarding the two distinct means of project funding was ultimately positive and hopeful. If the Rec Center were to try to put the weight of funding on the shoulders of the students, in terms of a referendum and slightly increased ASI quarterly fee, student feedback indicates that our conservatively calculated costs for such an implementation are fairly reasonable, or even small considering the impact of the changes. In addition, if the Rec Center were to fund the process of layout changes by redistributing their annual operational budget, student feedback indicates that taking some funds away from other Rec Center programs is not an innately bad idea. Rather, it would simply be expected that the choice of programs that receive decreased funding should be logical to both the staff and the student body. As a result, the business case of this project seems very hopeful, because whether it is funded by students, or the redistribution of the Rec Center’s budget, our project’s feedback indicates that the only issue of implementation is simply a matter of proper execution.

In conclusion, it is important to note that there are certain areas within our project that leave room for future efforts to benefit the Rec Center. One of the most notable is the investigation of different alternative design structures, regarding what rules were created for each design and how the equipment usage tier lists were utilized. It is also possible, as mentioned previously, that our process of student feedback could have yielded more conclusive results if only one alternative design was offered to be compared with the current layout. In addition, the scope of our project ended up focusing in on equipment usage imbalance more than any other aspect of the issue of overcrowding at the Rec Center. This is because both student feedback, as well as the input of the Rec Center staff, guided us to this specific area as the most critical result of the issue of overcrowding. Nonetheless, there are many impacts that overcrowding has at the Rec Center, and if time or effort was not a constraint, looking into these other impacts would have been a worthwhile endeavor. Aside from these potential areas for future effort to be contributed, we ultimately believe that our efforts were thorough enough to produce implementable, data-driven recommendations for each of the exercise room layouts. For that reason, we consider our project a success on many levels and hope that the Rec Center considers the results of our project in terms of how it can improve the average student’s overall experience at the facility.
APPENDIX

Figure 5 - [1st Floor] Work Sampling Group Sequence

Data Collection Sequence
- Group 1 – Isolation (middle; front-to-back)
- Group 2 – Isolation (left side; back-to-front)
- Group 3 – Compound (right side)
- Group 4 – Cardio (left side; front-to-back)
- Group 5 – Compound (middle)
- Group 6 – Cardio (back-right side; clockwise motion)
Figure 6 - [2nd Floor SMALL] Work Sampling Group Sequence

- Group 1 Cardio (front-left; front-to-back)
- Group 2 Cardio (front-middle; front-to-back)
- Group 3 Cardio (front-right; front-to-back)
- Group 4 Compound (middle)
- Group 5 Isolation (back-left; left-to-right)
- Group 6 Isolation (middle; right-to-left)
- Group 7 Isolation (front; back-to-front)

Figure 9 - 1st Floor - Equipment Utilization
Figure 10 – 2nd Floor SMALL – Equipment Utilization
[Figure 13] 2nd Floor SMALL - Conservative Layout

Removed Equipment
- 2 x Elliptical
- 2 x Precor bicycle
- 1 x Arc trainer

Added Equipment
- 1 x Smith machine
- 1 x Leg press isolation machine
- 1 x Dip/chin assist machine
- 1 x Pulldown isolation machine

= Inaccurate equipment model
Figure 15] 1st Floor - Aggressive Layout

Removed Equipment
- 2 x Elliptical
- 2 x Schwinn bicycle
- 1 x Curved treadmill
- 1 x Elliptiser
- 1 x Shoulder press isolation machine
- 1 x row isolation machine
- 1 x back extension isolation machine
- 1 x Biceps curl isolation machine

Added Equipment
- 3 x Flat bench press
- 1 x Squat rack

= Inaccurate equipment model
[Figure 16] 2nd Floor SMALL - Aggressive Layout

- Removed Equipment:
  - 4 x Arc trainer
  - 2 x Elliptical
  - 1 x Ergometer
  - 1 x Shoulder press isolation machine
  - 1 x Row isolation machine
  - 1 x Torso rotation isolation machine

- Added Equipment:
  - 2 x Fly/road delt isolation machine
  - 2 x Treadmill
  - 1 x Smith machine
  - 1 x Leg press
  - 1 x Dip/chin assist machine
  - 1 x Pulldown isolation machine

= Inaccurate equipment model

---

Test and CI for Two Proportions: conservative (1st), aggressive (1st)

Event = 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>X</th>
<th>N</th>
<th>Sample p</th>
</tr>
</thead>
<tbody>
<tr>
<td>conservative (1st)</td>
<td>33</td>
<td>112</td>
<td>0.294643</td>
</tr>
<tr>
<td>aggressive (1st)</td>
<td>39</td>
<td>112</td>
<td>0.348214</td>
</tr>
</tbody>
</table>

Difference = p (conservative (1st)) - p (aggressive (1st))

Estimate for difference: -0.0535714
95% CI for difference: (-0.175609, 0.0685463)
Test for difference = 0 (vs ≠ 0):  z = -0.86  P-Value = 0.390
Fisher’s exact test: P-Value = 0.475

[Figure 19] 1st Floor - Hypothesis Test Results
Test and CI for Two Proportions: (2ndSMALL)conservative, (2ndSMALL)aggressive
Event = 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>X</th>
<th>N</th>
<th>Sample p</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2ndSMALL)conservative</td>
<td>20</td>
<td>78</td>
<td>0.256410</td>
</tr>
<tr>
<td>(2ndSMALL)aggressive</td>
<td>40</td>
<td>78</td>
<td>0.512821</td>
</tr>
</tbody>
</table>

Difference = p ((2ndSMALL)conservative) - p ((2ndSMALL)aggressive)
Estimate for difference: -0.256410
95% CI for difference: (-0.403700, -0.109220)
Test for difference = 0 (vs ≠ 0): z = -3.41  P-Value = 0.001

Fisher's exact test: P-Value = 0.002

[Figure 20] 2nd Floor SMALL - Hypothesis Test Results
REFERENCES


