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Architectural Design of a WPI Concrete Structure

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Architectural Design of a WPI Concrete Structure

An Interactive Project
submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements
for the Degree of Bachelor of Science
by

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Abstract

Although WPI is a highly ranked university in terms of mathematics and engineering, the campus that it sits upon exhibits a disappointing lack of noteworthy artwork. This Interactive Qualifying Project outlines the design for a sculpture that would highlight the college’s academic strengths, while also providing much needed aesthetic appeal to the campus. The following report will outline the methods of designing a sculpture, choosing its location, and providing sufficient funding and approval for the artwork to be built.
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Executive Summary

The goal of this project was to design and realize the construction of an outdoor, concrete sculpture for the Worcester Polytechnic Institute campus. This artwork would not only serve to beautify the campus, but would also reflect the Institute’s expertise in science and engineering. To do this, six designs were developed, employing the mathematical concept of tensegrity. Making use of this concept, each design was characterized by its suspension of concrete members with steel cables, creating an illusion of floatation.

From the six designs, a single sculpture concept was chosen to be constructed at the college. This decision was made by drawing upon information from two very important sources. First, a survey was conducted in the Campus Center at WPI to obtain opinions of the students, faculty and staff on the different designs. When the results of the survey showed three sculpture concepts with very similar scores reflecting their popularity, another method was employed to narrow the selection of designs down to just one. For this, a list of pros and cons was made for each of the three sculpture concepts and was used to ultimately decide upon “Concrete Jungle.”

The previously mentioned Campus Center survey also aided in another essential step towards the realization of the sculpture: deciding upon its location. Five possible locations were proposed as potential sites for construction. Using the results of the survey, and considering recommendations made from qualified professionals at the Institute, the lawn in front of Salisbury Labs was chosen as the most appropriate site for the proposed sculpture.

With a sculpture design and possible location resolved, work continued on the steps necessary to bring the project to fruition. Research was completed and multiple meetings attended to investigate and settle such issues as: cost, funding, insurance and official approval.

To begin looking into any possible sources of funding, an approximate estimate of the
required cost first had to be calculated. Multiple professors with strong backgrounds in project management and cost estimating were very helpful in figuring the breakdown of costs for the project. Members of the project group then took these values to Alumni Relations at WPI, where they worked with the Major Gifts Officer to explore various potential sources of funding for the sculpture. In the end, a sponsor, the WPI Class of 1941, was found for the sculpture with sufficient enough funds to finance the cost of materials and construction in their entirety.

There was some uncertainty as to whether or not any special insurance considerations would need to be made for the sculpture. Although the design of the piece was essentially safe, there could be no assurance that failure would not occur. Working with the university’s head Compliance Officer, the matter was explored from various angles. Taking into account the size, location, and construction of the artwork, it was resolved that the sculpture would need to be covered under three different forms of insurance: that held by the contractor, builder’s risk insurance and that encompassing all of the property belonging to the Institute.

After all of the logistics had been worked out, and plans finalized, it was necessary to get official approval from the President of the university, Dr. Dennis Berkey. A meeting was arranged with President Berkey and the project team, in which the entire undertaking was presented to him. An information packet, poster and pictures were all on hand to illustrate both WPI’s current lack of artwork and the advantages of bringing more displays to the campus, especially that designed by the team. In the end, the President agreed whole-heartedly with the need for more works of artistic value, and gave the green light for construction of the sculpture.
Introduction

The construction of sculptures on college campuses became common practice throughout the United States in the 1960s and 1970s. It was suggested that removing these works of art from the sterile environment of the museum and placing them on the grounds of a learned institution would prove beneficial for both the reputation of the piece and those who viewed it. Here, people would encounter the artwork casually in their daily lives, instead of as an exhibit in a museum. An example of this is “Oval with Points”, one of the earliest known campus sculptures, created by Sir Henry Moore for Princeton University\(^1\). Campus sculptures provoke far more comprehensive and diverse responses than they would in a museum, since they are more frequently observed and serve as prominent parts of the campuses they are placed on. In this way, a sculpture can become integrated into the viewer’s life; acting perhaps as a meeting place between classes or the backdrop of a daily physics lecture. This kind of artwork adds beauty and culture to the surrounding environment, and inspires those within it.

Campus art can convey cultural statements to a young and intellectual audience, and act as attractive focal points on institutional landscapes. They are erected to both stimulate the minds of students, and to heighten the collegiate awareness of art\(^2\). The placement of these works of art proves that just as a college or university can serve as a center for innovative scientific research, it may also be the vanguard of artistic development.

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Worcester Polytechnic Institute is known for its position at the forefront of scientific and engineering studies and research. It is prominently ranked as one of the top schools in the nation. However, there is not a single piece of artwork that WPI can boast as innovative or inspirational. There are very few sculptures on WPI’s campus, and those present go unnoticed even by the students that pass them daily. This is due to the poor placement, unimpressive stature, and undistinguished and lackluster appearance of the works. Art is meant to be seen and felt; if it cannot fulfill this purpose, it loses its value to the community. Worcester Polytechnic Institute’s campus is in dire need of more artwork that will be both inspirational and an integrated part of student life.

Professors Tahar El-Korchi and Brigitte Servatius presented the idea of constructing a sculpture on the campus of Worcester Polytechnic Institute that would be substantial enough to be a landmark worthy of the established college that it would stand on. This suggestion stemmed from a trip to Hirshhorn Gardens in Washington D.C., where the professors were able to see Kenneth Snelson’s “Needle Tower,” a 60 foot high sculpture, constructed of aluminum columns that seemingly floated in the air. El-Korchi suggested that a sculpture using similar concepts be designed for WPI’s campus, but instead of aluminum it would be made from concrete. This artwork would be a microcosm of the fundamental qualities of WPI; its mathematical intensity and advanced construction techniques would proudly display the college’s fervor for science and engineering, while its attractively displayed message and artistic value would emphasize the last part of the school slogan, which reads, “The University of Science and Technology. And Life.” This project developed recommendations for the creation of a sculpture that meets and even exceeds those objectives. This IQP addresses the following topics necessary prior to the final
construction of the WPI sculpture: sculpture design, approval and permitting process, cost estimating, fund raising, and construction recommendations.
Background

Existing Artwork on the WPI Campus

The one structure on campus that stands out as the most attractive and noticed part of the college is the fountain at Reunion Plaza, pictured in Figure 1. Central to the WPI campus, the fountain is an area that is always populated, whether it is running or not. The fountain provides a much needed social environment and a place for students to read or do schoolwork. It is commonly used as a meeting point because of its prominent and central location. Although it may be the best artwork that the campus has to offer, it is remarkably uncreative and simple. This is certainly not at the forefront of artistic expression as it should be. Its redeeming qualities lie in its location and medium of water, not in its artistic value.

Figure 1. The Fountain at Reunion Plaza

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At the center of Freeman Plaza is a small granite pedestal containing a bronze sundial. The piece is marked with roman numerals around the outside of the plate, with a long arced gnomon to cast a shadow. The alidade rotates in a circular motion around the pedestal of this equatorial sundial to read the time\(^4\). However, although this is a remarkably attractive and scientific timepiece, it is a very small piece of artwork, and often unnoticed by the student body. The sundial certainly serves its purpose as an attractive timepiece, but it is not the kind of impressive and noteworthy sculpture that shows the artistic capabilities of the university.

![Sundial at Freeman Plaza](image)

*Figure 2. Sundial at Freeman Plaza\(^5\)*

Another neglected work of art on campus is the rusted metal structure found behind Kaven Hall. It is made of the same material as two similar sculptures that stand on each side of the library entrance. Bearing no markings, it is difficult to decipher the origins of these pieces or


their artistic intentions. The library sculptures are actually hidden by bushes, and the third sculpture is on the side of Kaven Hall opposite most activity. The inconspicuous placement and modest stature of these sculptures result in an unfortunate lack of appeal and lack of contribution to the campus as artwork. None of these pieces of outdoor artwork provides an artistic value and prominent reputation, as a college sculpture should.

*Figure 3. Sculpture Behind Kaven Hall*6

**Kenneth Snelson and Tensegrity**

Every project needs its inspiration, and for this particular undertaking, inspiration was found in the works of multiple artists employing a concept called tensegrity. This science/art form is described as the “synergy between co-existing pairs of physical laws”, including push

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6 Photograph by author.
and pull, and tension and compression\textsuperscript{7}. Taking advantage of not only this synergy, but also of other properties inherent to natural structure, including modularity and helical symmetry, artists practicing this technique are able to create seemingly complex structures with almost no limitation to their size\textsuperscript{8}.

These aforementioned properties serve as the backbone for any tensegrity structure, and have been revealed largely through the practice of weaving. The most familiar form of weaving is two-dimensional weaving, with its two basic patterns: the two-way plain and the three-way triangle hexagon, shown in Figure 4.

\begin{figure}
\centering
\includegraphics[width=0.5\textwidth]{weaves.png}
\caption{Two Dimensional Weaves\textsuperscript{9}}
\end{figure}

\textit{A. Two-Way Plain Weave}

\textit{B. Three-Way Triangle Hexagon Weave}

Artists like Kenneth Snelson have expanded upon these ideas to create weave patterns in three dimensional space. The most basic shape that can be made in this way is the X-frame structure, an intersection of two struts held together by four tension members (Figure 5). The X-frames can be combined to form varying structures, in the same way that crosses are combined to


\textsuperscript{9} Ibid.
create weave polyhedra. These weave polyhedra, or helix polyhedra, take basic three-dimensional solids and construct weave like cells from them. As with planar weaving, there are two basic modes of space weaving, these are the octahedron and the tetrahedron (Figure 6)\textsuperscript{10}.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure5.png}
\caption{X-Frame Construction\textsuperscript{11}}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{figure6.png}
\caption{Basic Modes of Space Weaving: Octahedron (left) and Tetrahedron (right)\textsuperscript{12}}
\end{figure}

It is upon these modules that all tensegrity structures are created. To begin, each weave filament becomes a strut, or compression member. Next, tension lines, usually constructed of steel cables, are used to connect the ends of each strut (Figure 7). This creates a “closed system of tension and compression parts.” The compression parts remain separated from one another, yet retain the module’s original shape due to the pulling action from the tension members. It is

\begin{itemize}
\item \textsuperscript{10} Ibid.
\item \textsuperscript{11} Ibid.
\item \textsuperscript{12} Ibid.
\end{itemize}
this balance of the struts’ tendency towards divergence and the cables’ towards convergence that is responsible for both the shape and strength of tensegrity structures\textsuperscript{13}.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure7.png}
\caption{Basic Space Weaves Constructed from Struts and Tension Lines: Octahedron (left) and Tetrahedron (right)\textsuperscript{14}}
\end{figure}

Once constructed, these balanced modules can be connected to one another in order to form larger and more diverse designs. In order to do this, the helical axes involved in each module must be considered. These axes are formed when one filament crosses over another, producing both a right-handed, clockwise rotation and a left-handed, counter-clockwise rotation. Accordingly, “each woven interaction produces its rotational complement”, as seen in Figure 4, in the two-way plain weave, where each cell’s neighbor is its mirror image\textsuperscript{15}.

The same is true for the three dimensional space frame. In a right handed module the direction of the push and pull, or tension and compression forces are exactly opposite those in the identical left handed counterpart. The tension forces pulling clockwise in a right handed module would pull counterclockwise in its left handed complement. Therefore, each module has a specific tendency toward rotation. If modules are arranged so that their helical directions are alternated, each form’s inclination to twist would be negated by its neighboring opposite. This

\textsuperscript{13} Ibid.
\textsuperscript{14} Ibid.
\textsuperscript{15} Ibid.
alternating pattern of helical directions not only provides a means of connecting these forms, but is also responsible for the flexibility of the structure created\textsuperscript{16}.

**Santiago Calatrava**

Spanish architect and engineer Santiago Calatrava is known for his impressive structural work in designing many elaborate bridges and skyscrapers. He has also created several small scale sculptures that share characteristics with Snelson’s works. While utilizing similar concepts to balance compressive and tensile stresses, Calatrava introduces a new dimension to his works which compliment their already unique style. Within his sculptures varying three-dimensional shapes, instead of simple cylinders, are suspended by the tensile forces of the cables that hold the sculptures together\textsuperscript{17}. His sculptures concentrate on the relationship between empty spaces and the spaces occupied by these floating objects, and often his architectural designs are based on these small works. The look of large, heavy objects that appear to be floating weightlessly is central to the appeal of Calatrava’s art, and is an element which was also considered in the design of new artwork for WPI.

**Environmental Art**

The proposed sculpture is a site-specific and environmental sculpture, a concept that became prevalent during the pop art movement. A sculpture of this type is designed to be integrated into its surroundings; in that way it is not an exhibit, but it is a place, one that a viewer may experience rather than observe. Often, environmental sculptures are on a large enough scale

\textsuperscript{16} Ibid.

for a person to walk inside of and become encompassed by them. Robert Smithson, a pioneer of this form of art, actually altered land masses to form enormous pieces of environmental sculpture. His most recognizable work, “Spiral Jetty,” is a 1500 foot spiral rock formation that extends into the Great Salt Lake (Appendix B)\textsuperscript{18}. These pieces are obviously characterized by their enormous size, which enables them to be so openly absorbed by the viewer. Other popular large-scale environmental sculptures, like Claes Oldenburg’s “Spoonbridge and Cherry,” and Christo’s “Running Fence” utilize these same techniques (Appendix B)\textsuperscript{19}. Many of Kenneth Snelson’s works are environmental in that the viewer can actually walk underneath or through them to experience the pieces from all angles. The sculpture designed in this project will employ the concept of environmental art as well as those used by Snelson and Calatrava as mentioned above.


Preliminary Design Concepts

Following the exploration of such artistic styles as those practiced by Kenneth Snelson and Santiago Calatrava and the characteristics of environmental artwork described above, the members of the project team began creating original designs. Each member immediately took to working on a personal and individual design. Although critiques were made and improvements suggested by all, after several weeks, each student presented a sculpture proposal. Although each model offered a different and distinctive appearance, they were all unified in their use of colored concrete and mathematical design. These proposed sculptures and their construction are described below.

A Closer Look

“A Closer Look” was designed with the works of Kenneth Snelson directly in mind, meant to closely replicate the appearance of his structures. Tensegrity was employed to model a piece of artwork that would not only grasp the viewer’s attention, but would also serve as a reflection of the WPI spirit. To do this, the sculpture was designed and constructed in such a way as to give the illusion of floating members, just as can be seen in sculpture designs by Snelson. The pattern of these members would appear completely random when viewed from the sides, no one view the same as any other (Figure 8a). When observed from the top however, all of the parts of the sculpture would come together to form the letters W-P-I (Figure 8b).

The proposed design would be composed of two materials: lightweight concrete and steel cables. The lightweight concrete would be used to construct the struts, the compression bearing members of the sculpture. It was these struts which were to be used to form the letters W-P-I. Additionally, these concrete pieces would also be colored to add to the appeal of the sculpture.
Following the theme of the WPI spirit, the colors chosen were crimson, gray, and white, which are the official colors of the school. Connecting these struts were the steel cables. This component could provide the tension forces necessary to retain the shape of the design, while still allowing for the flexibility of its sculpture. Visually, their thin profile was nearly invisible when viewed from a distance, helping to create the intended illusion of floatation.

![A Closer Look Model](image)

**Figure 8. “A Closer Look” Model**

A. Side (Ground) View

B. Plan (Bird’s Eye) View Making Visible the Letters W-P-I

**Perspective**

“Perspective” too was designed to display the spirit of WPI through a visually complex work of art. Again, the members comprising the sculpture would come together to form the letters W-P-I; however, for this design, they would do so with an entirely different viewpoint. “Perspective” was modeled in such a way as to enable viewers to easily distinguish the letters when observing from ground level. To do this, the members in the foreground were placed to form the recognizable outline of W-P-I (Figure 9). From these, steel cables were attached and

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20 Photograph by author.
drawn back, approximately fifteen feet, where they were to be anchored into the ground. Two sets of identically shaped additional struts were then attached to these cables, becoming progressively smaller as they move away from the front of the piece. Each outline that these members form would align from the proper line of sight so that each set of members would be a shadow of those in front of it.

Although the description of the design is somewhat convoluted, the materials proposed to construct it are simple; strictly lightweight concrete and steel cables. The compression and tension members of the sculpture were formed and assembled in a fashion very similar to that for A Closer Look. Again, colored concrete was planned to shape the struts forming the letters and steel cable employed to retain the sculpture’s overall form and flexibility.

Figure 9. Preliminary Model of “Perspective”
A. Front (Ground Level) View
B. Plan View

Photograph by author.
Concrete Jungle

Similar to the other proposed sculptures, Concrete Jungle was to be constructed from colored concrete and steel cables. It utilizes tensegrity to hold each “branch” of the tree apart from the others as if they are floating.

The proposed sculpture stands 15 feet tall and 10 feet wide. The central column is brown colored concrete; about 12 feet high and 16 inches in diameter. Anchored to that column are three webs of tensegrity formations. Each of these webs consists of six green concrete cylinders, 4 inches in diameter and ranging in length from 2 feet to 8 feet. The cylinders are connected by lengths of steel cable, sixteen per web, attached to the concrete cylinders using steel clips. The lowest part of the sculpture, excluding the main column, would hang 10 feet above the ground as to remain out of reach.

The mathematic value of the structure lies in the tensegrity. The three branches of concrete cylinders are varying combinations of X-frames, a tensegral formation mentioned earlier. The lengths of the members in each of the X-frames differ greatly so that each one has a different shape. The X-frames are linked together by drawing a cable from each end of the X-frame to the opposite ends of the second X-frame. Each of the X-frames has a left or right rotation based on the manner in which the cylinders overlap, and that rotation must be opposite between any two structures that are linked for tensegrity to take effect. Three of these formations are linked together to create each branch.

The actual artistic concept of the sculpture must of course have theory supporting it as well. The colors of the concrete and arrangement of the members represent a tree; it is a green web of branches supported by a thick brown trunk. The concept behind such a design is to produce a living and natural image from a highly mathematical process, using a synthetic

22 “Kenneth Snelson.”
medium. The branches will even sway in the wind, as a tree would; adding an animate dimension to the piece. The artwork juxtaposes the man-made construction materials from which it is formed with the natural image that it depicts. The resulting contrast is provocative yet aesthetically pleasing.

The model of this sculpture shown in Figure 10 is built at roughly a 1 inch to 1 foot scale. It is a revised version of two preliminary models that were created using similar methods, and is constructed using a 7/8 inch diameter wooden dowel for the main column and 3/16 inch diameter wooden dowels for the cylinders. The steel cables are represented by elastic strings, and are fastened to the cylinders with thumbtacks at each end. The cylinders are linked together using the same tensegral methods that would be used in the full scale sculpture and described above. However, the branches would be attached to the trunk at the ends of the cylinders, instead of through a point in the middle as they are in the model. The model is also painted colors similar to the colors that the concrete would be.

Figure 10. Model of “Concrete Jungle” Design

Photograph by author.
Like Clockwork

The concept guiding the design of “Like Clockwork” was the creation of a piece of artwork that was not only visually pleasing, but also functional. “Like Clockwork,” as it was proposed, served as both a place to sit and a means of telling time. The multi-part structure closely resembled the face of a clock. Benches were projected to form the outer boundary of the face, and a set of operating clock hands were suspended several feet above to display the time (Figure 11). The idea to suspend such a large component in the air, seemingly floating, was directly influenced by the works of Santiago Calatrava.

![Figure 11. Preliminary Model for “Like Clockwork”](image)

A. Side View  
B. Plan View

The diversity of materials necessary to construct “Like Clockwork” was far greater than that for the other proposed designs. At first glance, the sculpture’s composition appeared simple. The benches, platform and even the clock hands were all designed to be shaped from concrete. Just as for the other models, steel cables were proposed as the means for suspending the hanging component. The movement of these hands however, would not be possible without some degree

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24 Photograph by author.
of mechanics. The sculpture would consist of a sizeable motor and gears as well as electrical components to power the clock. Bringing it all together, it was anticipated that a person standing on the platform of Like Clockwork, could look above his or her head to determine exactly what time it was. Additionally, with the sun directly overhead, the shadow cast by the clock hands on the ground would also tell the time.

**Equilibrium**

Similarly to “Like Clockwork,” “Equilibrium” was greatly influenced by the works of architect Santiago Calatrava. Employing elaborate balances between the forces of tension and compression, “Equilibrium” featured the illusion of massive shapes seemingly floating in precarious positions. These shapes included both spherical and cube-like objects, all of which were suspended in a helical pattern as seen in Figure 12. The entire structure was planned for construction above a walkway. It was anticipated that this would promote the audience to not only view the art, but to also engage in it while walking under the shapes suspended in its design.

*Figure 12. Plan View of “Equilibrium” Model*²⁵

²⁵ Photograph by author.
In order to create the desired floating effect, while maintaining enough free space to allow for an adequate foot path underneath, Equilibrium made use of four large columns. These columns were to be molded from concrete, and served as the anchoring means for the entire structure. It was only at these four points that the artwork came into contact with the ground; the spheres and cubes remained completely overhead. These concrete bodies were hanging in balance, the overall shape sustained by the forces developed in the steel rods and cables connecting them to one another and to the columns. Although composed entirely of concrete and steel cable, the spheres and cubes of “Equilibrium” were colored crimson, gray and white, which brought a variety of color to an already varied geometry.

**Floating Blocks**

The sixth and final concept was titled “Floating Blocks.” Probably the most simple of all the designs, the appearance of “Floating Blocks” resembled that of an ordinary spiral stairway. Five equal sized cubes were positioned in an ascending pattern, each cube at a slightly greater height than its previously placed counterpart (Figure 13). Unlike an ordinary stairway however, the blocks comprising the stairs seemed to be suspended in mid-air.

In order to achieve the described effect, four columns of multiple heights were constructed at the four corners of a square base. Steel cables were then used to attach the cubes to each other and to the columns. The cubes were to be constructed from colored concrete, alternating between red and black. The columns were to be formed from the same material. As with the other pieces, the basis of this sculpture was the suspension of heavy shapes in a visually attractive manner.
Figure 13. “Floating Blocks” Model
A. Side View
B. Plan View

Photograph by author.
Potential Locations

Almost as important as the design of the sculpture was the location at which it would be placed. The site of any piece of artwork can determine who sees it and how often, and may even affect how its viewers feel about it. With this in mind, a list of possible locations was compiled and each prospective site evaluated on certain criteria. Depending on the results of the individual evaluations, each option was either discarded or maintained as a prospective site. Finally, the initial list was narrowed down to the five most favorable possibilities.

To begin the process of determining prospective locations, it was necessary to consider all potential sites. First, the group considered all open plots of land on the WPI campus with which they were familiar. Then, to ensure that no location was overlooked, members of the group walked the entirety of the campus in search of additional options. Any new findings were added to the initial list, resulting in an extensive catalog of approximately twenty potential locations.

Of these many locations, it was decided that the most favorable would need to be determined in order to effectively continue exploration of the different designs. To do so, the fundamental elements of an ideal location were discussed and the critical factors were settled on as: proximity to the center of campus, the average amount of foot traffic experienced and any possible role in long standing traditions or histories.

To elaborate, the proposed sculpture was intended to become an integrated part of the WPI campus, complementing the simple architectural styles of the existing buildings while reflecting the university’s focus on creative sciences. To truly be considered as a part of the campus however, it was important to ensure that the sculpture was constructed at a central location. This, it was hoped, would prevent the structure from becoming nothing more than a
footnote to campus, like the existing sculptures. Likewise, the greater the pedestrian traffic at a certain location, the greater the number of people to pass by and view the art constructed there. Furthermore, the WPI campus is home to a number of traditions and historical happenings. Therefore, it was important to choose a construction site that would not interfere with the preservation of these customs and landmarks. For example, each year the commencement ceremony is held on an area of campus known as the Quadrangle. The construction of a fairly large sculpture at this location could thus prove problematic at the time of this celebration, so alterations to the design may need to be considered if it were to be erected there. Similar considerations were made for each proposed location until the extensive list of options had been reduced to only the five top locations, which are examined below. A map showing each of the potential locations can be found in Appendix C.
Salisbury Labs Lawn

The first of these five possible sites was the lawn in front of Salisbury Labs, on the side adjacent to Olin Hall (Figure 14). This location was deemed appropriate for several reasons. First, Salisbury Labs is located almost directly in the center of campus. Most students, faculty, staff and visitors pass by the building en route to many campus facilities. This central location results in a great amount of pedestrian traffic around the area, and therefore, a great number of viewers. What may have made this location ideal however, was the fact that the Humanities and Arts Department is located within Salisbury Labs. Erecting such an artistic structure outside of Salisbury Labs would therefore provide a pleasant compliment to the department housed inside the building.

Figure 14. Photograph of the Lawn in Front of Salisbury Labs

Photograph by author.
Skull Tomb

The second potential location for the construction of the sculpture was the area surrounding Skull Tomb. Located along the southernmost edge of campus, this site offered a rather spacious, flat, and open area, as seen in Figure 15, which is exactly the reason it was considered. Aside from this characteristic however, erecting a sculpture at this site would be unfavorable. Positioned at the outer edge of the WPI campus, the Tomb and its surrounding land are uncommon destinations and would not be often viewed. Furthermore, the site is a large part of the school’s history, and alteration of the landmark or its immediate area may not be looked upon fondly.

Figure 15. Photograph of the Potential Location Next to Skull Tomb

Photograph by author.


Main Entrance

The third area was the main entrance to the WPI campus, located just off of Institute Road, adjacent to Alden Hall (Figure 16). This location was chosen for its high volume of traffic, including both pedestrian and vehicular. As the main entrance to the school, this is where the most people enter and exit, and therefore where the artwork would perhaps attract the greatest audience, one comprised of both members and non-members of the WPI community. Unfortunately however, construction of a sculpture at the entrance would only be possible if the artwork were to be situated along the steep sloping ground to the right of the driveway, which makes the proposition less feasible.

Figure 16. Photograph of the Main Entrance to the WPI Campus

Photograph by author.
Higgins House Gardens

The gardens at Higgins House provided another possible location for the sculpture. The Higgins House Gardens are frequently visited by students, faculty and staff for their beautiful greenery and relaxing environment. It seemed only appropriate, that an area already frequented for its aesthetic assets would be considered for the addition of artwork. In the end however, the site proved unpopular among group members. Higgins House is located on the outer edge of campus, and therefore experiences very little foot traffic. Although the gardens do attract sightseers, they are not passed on a daily basis, or by routes commonly taken by the WPI population. Furthermore, there was some concern that such a modern looking addition, as was proposed by the project, would take away from the natural and simplistic beauty of the gardens.

Behind the Campus Center

The Campus Center is the central gathering point for most students, faculty, and staff on the WPI campus. As such, it was only appropriate to consider the area surrounding it as a possible location. Following inspection of the building, it was decided that the most favorable location for a moderately large sized piece of artwork around the Campus Center would be on the directly behind it. Although not much foot traffic is present at or around this area, the back lawn can be seen from almost anywhere in the building. As a result, if the structure were to be constructed at this location, the number of viewers in very close proximity the artwork would be relatively smaller than at the other sites. The audience observing it from inside the Campus Center however, would probably be far greater than the “indoor” audience at any other of the proposed locations.
Recommendations from Plant Services

The five possible locations were examined by each member of the group for any problems that may arise should they be chosen as the site of the new sculpture. Analysis was limited however, primarily to the three factors previously mentioned: proximity to the center of campus, the average amount of foot traffic and any preservation concerns. The group had little knowledge concerning the feasibility of the actual construction. For this, the WPI Plant Services department was contacted, and a meeting was arranged with the Director of the Physical Plant, John E. Miller to discuss the implications of any, or all, of the chosen sites.

Among the points discussed at the conference, Miller rejected only two of the possible locations. First, he expressed concern over placing the sculpture at Skull Tomb. This was a historic site, and, he believed, should be preserved as such. The second spot to be eliminated

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Photograph by author.

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30 Photograph by author.
from the list of options was the Main Entrance to the campus. Not only was the terrain at this site very steep, but it was located rather close to a public roadway. Furthermore, the traditional look of the entrance, resulting from the presence of the footbridge and Alden Hall, could be destroyed by the construction of some modern looking artwork there. Two of the potential locations, Higgins House Gardens and behind the Campus Center did not spark much of a discussion. Although Miller could see no immediate issues with these locations, he was personally not fond of placing the proposed sculpture at either one. The lawn in front of Salisbury Labs however, he stated, was “most crying for artwork” and would be very feasible to build upon. Further discussion made it clear that this location was indeed the one he would recommend.
The Surveys

The design of the sculpture would be completed by only six individuals, yet was hoped to appeal to thousands. In order to ensure this, the WPI students, staff and faculty were surveyed at two different stages of the design process. At the beginning, a one-question poll was posted on myWPI. As the project progressed, another survey was conducted; this time more detailed and personal. The results of these surveys confirmed support for new artwork on campus and assisted in the decision on a final concept.

myWPI Poll

It was clear that the WPI campus was severely lacking in its display of artistic works, however, there was some uncertainty as to whether or not the community cared to change this. Ideally, each student, staff and faculty member could have been questioned to determine the prevailing attitude on the subject; this however, would have proved a very cumbersome task. As a result, an alternative approach was taken. It was decided that the most effective way to gain an understanding of the amount of support for new artwork on campus would be to post an inquiry on myWPI.

The myWPI site is accessed daily by most of the WPI population, for various reasons (i.e. homework assignments, grades, miscellaneous announcements). It therefore provided an excellent opportunity to reach a great number of people in a very short amount of time. This opportunity would be wasted however, if few individuals took the time to complete the questionnaire. Thus, in order to ensure a great return rate on the survey, only one question was posted on the site. This read, “I would like to see more outdoor artwork on campus”, and participants were instructed to choose one of the following responses: agree, disagree and
indifferent. Nearly 1,500 people completed the poll, most of which submitted a positive response. The results are shown in Table 1. At its conclusion, the census demonstrated a great show of support for the addition of new artwork on the WPI campus.

<table>
<thead>
<tr>
<th>Response</th>
<th>Number of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>978</td>
</tr>
<tr>
<td>Disagree</td>
<td>236</td>
</tr>
<tr>
<td>Indifferent</td>
<td>372</td>
</tr>
</tbody>
</table>

Table 1. Results of the myWPI Poll

The Campus Center Survey: Design

Six models and five possible locations were proposed as options for the design of the future sculpture. The project at hand, however, only called for one. As a result, the choices had to be narrowed down and a final concept had to be chosen. Saying no to any one design proved rather difficult though, since so much work had been done so closely with all of the models. Hence, it was decided to draw upon the opinions of others who had no connection to the project, but held a vested interest in its realization: the campus community. It was hoped that feedback from students, faculty and staff would aid in choosing the best design. The only problem was finding a way to obtain these crucial opinions. The solution came in the form of a survey.

Before the survey itself could be drafted however, its objectives needed to be clear. The survey had a few different purposes. It had to determine the general attitude toward bringing more outdoor artwork to the WPI campus. It also needed to gain a better understanding of what kind of artwork the campus community would most like to see integrated on the institute grounds, as well as determine at what location students and staff would most like to see such artwork constructed.
The survey had to be designed in such a way to meet each one of these objectives. After researching multiple survey design sources, including Arlene Fink’s The Survey Handbook, and reviewing existing sample questionnaires, the layout of the form was chosen. Various question types would be employed, both closed and open ended, and additional space would be provided for any comments. This would allow for a fairly easy analysis of most of the results, but also a chance to garner constructive opinions not restricted by a list of pre-determined answers. Each of the survey questions are examined below.

Question 1:

I would like to see more outdoor artwork on the WPI campus.

1  2  3  4  5
Strongly Agree  Agree  No Opinion  Disagree  Strongly Disagree

This question is very similar to the myWPI survey question, except that there is a greater range of options for the answer. This question is a simple one; it essentially serves as a “warm-up” for the rest of the survey. The responses to this question were not crucial, since 1,500 responses were already obtained from this question which is a large enough sample.

Question 2:

Please rank each design according to which you would most like to see on campus (1 being your first choice, and 6 as your last).

A Closer Look ________ Like Clockwork ________
Perspective ________ Equilibrium ________
Concrete Jungle ________ Cubic Staircase ________

Why did you choose this as your number 1?

This question is meant to determine which design is the most liked by the participants by counting the number of people that chose each sculpture as number one. However, since every one of the sculptures will be ranked from one through six, the responses from this question can also be tallied in such a way to determine an overall score. This is to account for a case in which a sculpture did not have many number one votes, but was consistently highly ranked. Both of these results were considered. The open-ended follow up question, which asks why the participants chose their favorite sculpture is designed to obtain information about the best qualities of each design. This information was used to consider any changes that were to be made to the designs, as well as to evaluate the seriousness of the subject of the survey. If a participant responds very thoughtfully to this question, his answers are probably more valuable.

Question 3:

Where would you like to see your #1 constructed on campus? Please give us your top three choices (1 being your first choice, and three being your 3rd).

Location 1: In front of Salisbury Labs
Location 2: The area near Skull Tomb
Location 3: Institute Rd. entrance to WPI
Location 4: Higgins House Gardens
Location 5: Behind the Campus Center

The thought process behind this question is similar to the last. The purpose behind the question is simple to see which location is best liked by the participants. Since the participants may not be able to picture each of the locations or may be unsure about them, they were only asked to rank their top three choices.
Question 4:

Please provide any additional comments (likes, dislikes, necessary changes, etc.) on any of the designs.

A Closer Look: ______________________________________________________________
Perspective: ________________________________________________________________
Concrete Jungle: _____________________________________________________________
Like Clockwork: _____________________________________________________________
Equilibrium: ________________________________________________________________
Cubic Staircase: _____________________________________________________________

This is the final and most open-ended question on the survey. It is designed to gather input about each one of the designs that was to be evaluated when making considerations about changing the designs. Constructive comments about a sculpture would be used to make further improvements to the artwork before finalizing the design.

With the final draft of the survey completed, and ready to be filled out, the manner in which it would be administered needed to be determined. It was important to choose a method through which a representative cross section of the entire campus community could participate; that would collect feedback from all classes of students and faculty from every department. It was decided to look for volunteers in the one place on the grounds where they could all be found, which is the WPI Campus Center. Conducting the survey here allowed not only for a diverse sample of the community population, but also allowed for a large number of people to respond to the survey since it is a very common campus destination.

The survey to obtain the opinions of WPI students and faculty took place on January 26th, 2007, between 9:00 AM and 3:00 PM. A table was reserved in a high traffic area of the Campus Center, at which anywhere between two and five members of the group sat to administer the survey and ask for input. To prepare for this event, 100 copies were made of the written survey described earlier. The models, along with short descriptions of each, were displayed on the table
for the students to use in their decision. A poster showing the possible sculpture locations was hung from the table to help students imagine the places described in the survey, and colored concrete samples were present at the table to further stimulate student interest. The interactive manner in which this survey was given allowed for more thoughtful responses by the participants. It also allowed the participants to ask any questions they might have about the sculptures and served to stimulate interest about the project.

**The Campus Center Survey: Results**

The survey was filled out by a total of 63 people; an encouraging return rate considering the length of time required to participate. The opinions of a few students who did not have time to fill out the survey were also marked down and included in the results. The estimated total number of people that passed by the table during that time period is about 500 people. This yields a response rate of 13%. Since the survey is passive, in that only those that approached the table were asked to participate, high response rates were not expected. The goal of the survey was to provide insight, and in that situation the actual return rate is not extraordinarily important. For these reasons a sample size of 63 participants was deemed large enough to draw results about the proposed designs and locations. This sample would not have been large enough to determine whether WPI students would like to see more outdoor artwork on campus, since that is not a question designed to gain insight, but a large enough sample was already obtained for this question using the myWPI survey.

The results of each survey question were interpreted in such a way that they could most easily be understood. The results are shown below.

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Question 1:

I would like to see more outdoor artwork on the WPI campus.

For this question, the numbers for strongly agree, agree, no opinion, disagree, and strongly disagree were simply tallied and graphed. The graph shown in Figure 8 depicts the overwhelming support for artwork at WPI. Thirty-two people strongly agreed that there should be outdoor artwork on campus, 24 agreed, and 3 had no opinion. No one disagreed with the statement.

![Artwork on Campus?](image)

*Figure 18. Question 1 Results: “I would like to see More Artwork on Campus”*

Question 2:

Please rank each design according to which you would most like to see on campus.
In this question the participants were asked to rank the sculptures in order from their favorite to their least favorite. This method is similar to instant runoff voting, a method in which all of the options are ranked in case there isn’t a clear majority\(^33\). The scores were computed by inverting the values given on the survey, so that a greater numerical value represented a higher ranking; a one became a six, a two was a five, etc. The numbers were then summed for each design so that a higher score denoted greater support for a sculpture. These results are presented in Table 2. This yielded three top designs with very close scores: Floating WPI, Floating Blocks, and Concrete Jungle. Following that was Floating Equilibrium, WPI Perspective, and Bob. The number one rankings of each piece were also added up to show which sculpture the most people recorded as their favorite. Floating Blocks was at the top of this category, receiving 18 votes.

**Table 2. Total Scores for Individual Designs**

<table>
<thead>
<tr>
<th>Design</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bob</td>
<td>153</td>
</tr>
<tr>
<td>Floating WPI</td>
<td>252</td>
</tr>
<tr>
<td>Jungle</td>
<td>247</td>
</tr>
<tr>
<td>Blocks</td>
<td>251</td>
</tr>
<tr>
<td>Perspective</td>
<td>198</td>
</tr>
<tr>
<td>Equilibrium</td>
<td>219</td>
</tr>
</tbody>
</table>

**Question 3:**

The next question asked the participants to rank their favorite three of the five possible sculpture locations chosen earlier. The results were analyzed in the same way as the design choice; a one became a three and a three became a one. The unranked locations received zero points. Those results are shown in Table 3. The grass in front of Salisbury Labs was the clear favorite.

favorite here, obtaining far more votes than the second place choice of the area behind the campus center.

**Table 3. Question 3 Results: Total Scores for Individual Locations**

<table>
<thead>
<tr>
<th>Location</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salisbury Labs Lawn</td>
<td>124</td>
</tr>
<tr>
<td>Skull Tomb</td>
<td>64</td>
</tr>
<tr>
<td>Main Entrance</td>
<td>70</td>
</tr>
<tr>
<td>Higgins House Gardens</td>
<td>16</td>
</tr>
<tr>
<td>Behind the Campus Center</td>
<td>76</td>
</tr>
</tbody>
</table>

The final part of the survey provided a space for comments about each one of the sculptures. As expected, not all of the students filled out this section of the survey, but the comments given were used to further analyze the sculptures and to decide on any improvements that could be made to them. The specific comments made can be found in Appendix H.
The Final Design

Choosing the Final Sculpture Design

The survey conducted at the Campus Center was a great help in determining which structure would be most likely to appeal to the WPI community. Although no single design concept could be declared the absolute favorite, the results of the survey did present the three most preferred sculptures: Floating WPI, Concrete Jungle and Floating Blocks. It was decided that the final design would be chosen from one of these three public favorites.

Eliminating any of these designs proved extremely difficult, as each had many positive qualities. Thus, it was decided that a list of pros and cons should be made for each of the three proposed sculptures in order to facilitate in the choice of the final concept. The complete list of pros and cons can be found in Appendix J. Upon completion of the list, Floating Blocks was the first model to be removed as an option. Concerns over its cost, maintenance and ambiguity resulted in the greatest number of negative comments.

Of the two remaining concepts, Concrete Jungle and Floating WPI, each received similar numbers of pros and cons, and a difficult decision had to be made. After a great deal of discussion, Concrete Jungle was chosen as the design which the group would propose for construction. Although there were reservations concerning the complexity of its design, Concrete Jungle was ultimately chosen for its creative synthesis of technical intricacy and organic beauty.

Choosing the Final Location

Compared to the lengthy and difficult process taken to decide upon the final concept, determining its location was simple. From the results of the surveys collected at the Campus
Center, it was concluded that the lawn in front of Salisbury Labs was the site at which the most members of the WPI community wished to see a sculpture erected. The recommendations made by John Miller of Plant Services, also pointed to this site as the most favorable for construction. The members of the group agreed, and so it was decided that Concrete Jungle would best be built at the lawn on the West side of Salisbury Labs.
Costs

Funding

As soon as the specific design for the sculpture was finalized. It was possible to move ahead and attempt to obtain funding for its actual construction. Since this process could have been a limiting factor in bringing the project to fruition, research began immediately.

Dexter Bailey, the Vice President for Development and Alumni Relations was contacted to investigate the possible courses of action to obtain funding for a project like this. He referred the group to Donna Stock, the Major Gifts Officer. A meeting was scheduled to discuss options for raising funds on February 19th, 2007. She offered three possibilities to be researched, which were: to obtain a monetary gift from Worcester Polytechnic Institute Alumni, a construction company that had ties to WPI could do the work free of charge, or a grant from an organization to support the arts, like the Massachusetts Cultural Council. With further research into these options, it was found that alumni from the class of 1941 had generated a fund to give to WPI for a similar project involving outdoor artwork on campus. Since the funds raised had not yet been allocated for a particular project, this project fit the criteria for becoming a potential recipient. After another meeting with Donna Stock to discuss the details of this possible contribution, a lunch Meeting was scheduled with members of the Class of 1941.

On April 23rd, 2007, Matthew Fuhrmeister, Mike Fecteau, Kyle Kappmeyer, and Joseph Sinagra met with Donna Stock, Barbara Ziff, the Executive Director of Advancement Operations and Research, and Gordon Gurney, Claire Gurney, Vic Kolesh, and Len White, representatives of the class of 1941. At this meeting, over lunch at Higgins House, The members of the group presented the proposed sculpture using an informational packet (Appendix M) and the final model as visual aids. After a discussion of the specific details of the project and the costs
associated with it, the representatives voted unanimously to offer a gift of $16,000 to fund the construction of this artwork. This agreement came under the conditions that the group would investigate the use of stainless steel cables to hold the concrete members together, the group would investigate the possibility of integrating some kind of lighting into the project, and that there would be a plaque mentioning the class of 1941 as the contributors of the sculpture. It was also required that a monthly report be given to the chairman of the class, Gordon Gurney, specifying the progress made and outlining the future plans. A contract was written that noted all of the terms of the agreement, edited by Donna Stock and sent to Gordon Gurney. This gift of $16,000 was more than the estimated cost of $11,700, proving this meeting to be very successful. Now that construction funds are available, the next phase of structural design, construction planning, and construction will be undertaken by a future WPI MQP project.

**Cost Analysis**

In conjunction with the research into the determination of a source of funding, after a final model had been produced a cost analysis was necessary to evaluate the feasibility of the funding alternatives. The cost analysis needed to account for the full cost of materials, equipment, and labor that were required to complete the sculpture.

Meetings with Civil Engineering Professor Guillermo Salazar and Civil Engineering Professor Frank DeFalco were scheduled to determine the processes necessary to accurately price the sculpture. Following suggestions from both professors, the costs were derived from standard tabulated values for construction and a 25% contingency was added to the total. Each part of the construction process was divided into material cost, equipment cost, and labor cost. Quotes were found for each of these items based on the standard Massachusetts rates from
the National Construction Estimator database\textsuperscript{34}. The complete list of costs is shown in Appendix K. Each item of the cost analysis is determined based on the quantities necessary for the current design and the hours estimated for each portion of the labor. However, since the dimensions, materials, or prices could change for the actual construction, and the labor time estimated are subject to changes due to unforeseen conditions, the additional 25\% contingency was used. The total cost of the sculpture was calculated to be $11,700.

Insurance

The chosen concept for the sculpture was designed according to a mathematical concept based on balance. Upon its construction, large concrete cylinders would be suspended approximately 15 feet in the air, held only by the balanced forces of the total system. The result was an impressive image, but also a daunting one. Although designed to be completely stable, one could never be too sure that a failure could not, or would not occur. Thus, it was necessary to explore the role that insurance would play in the construction of such a work of art.

Working alongside WPI’s University Compliance Officer, Michael Curley, the sculpture was explored from all relevant aspects of its concept. The design, location and construction of the piece were all investigated in terms of their impact on stability, longevity, size and cost. In the end, it was determined that three forms of coverage would be involved in the insuring of the sculpture; these included the policy held by the future contracting company, that assuring all of WPI’s property and also builder’s risk insurance. As far as the university was concerned, the sculpture would simply be added in the tabulation of the campus’ square footage, and insured as lumped with these other properties. The builder’s risk insurance would serve to cover both WPI and the contracted company during the construction of the sculpture, from risks including theft, vandal, accidental losses, etc.\(^\text{35}\). No additional coverage was necessary however, in spite of the sculpture’s seemingly dangerous design.

\(^{35}\) Michael J. Curley, interview by author, 31 January 2007, Worcester, MA.
Official Approval

For this sculpture to eventually be realized, it was necessary that it be approved by the appropriate WPI administration. After the completion of the design, survey and decision of location, a meeting was scheduled with Dr. Dennis Berkey, President of Worcester Polytechnic Institute. This meeting was held on April 18th, 2007, and was attended by every member of the IQP group, President Berkey, and assistant to the President, Stephanie Pasha. The purpose of this meeting was to present the proposed sculpture to obtain the feedback and support of the President since he is the most influential single member of the WPI community.

To prepare for this meeting, an informational packet outlining proposal was emailed to President Berkey and Stephanie Pasha, two days prior. This packet, shown in appendix M, gives an overview of the design of the artwork, the chosen location, and the results of the survey of the campus community. A two foot by three foot poster was also brought to the meeting as a visual aid, including photographs of Kenneth Snelson and Santiago Calatrava’s works, pictures of the possible locations, the final model, and a drawing of the sculpture in the proposed location. The final model and photographs of the other possible locations and designs were also supplied as visual aids.

The presentation to President Berkey began with a description of the proposed sculpture and the thought process behind it. The group also explained the steps taken to ensure that this project was a possibility; the meetings with John Miller from Plant Services, Mike Curly, the University Compliance officer, and Donna Stock, the Major Gifts officer. The results of the both surveys done were also presented.

President Berkey’s reaction was very positive, although he did express some concern for the structural integrity of the sculpture and potential for risk. He also suggested that we remain
open to using a different material, he wholeheartedly agreed that the campus is in need of more artwork. He thought that the artwork was both attractive and provocative, and that it would provide a great compliment to the campus. He gave his full support to the group and the continuation of the project, and mentioned that he can provide help if it is necessary. Both Stephanie Pasha and President Berkey also noted that the presentation was very impressive and well organized. This was an excellent response; and the goal for the meeting of obtaining support was definitely met.
Discussion / Conclusion

After 21 weeks of work on the design and realization of a sculpture to be integrated into the WPI campus, the project can be considered a success. Not only was a sculpture designed that is both beautiful and representative of the Institute’s talents, but all of the requirements necessary for its construction have been met. Concrete Jungle, to be built on the lawn outside of Salisbury Labs, will showcase the university in a much needed different light. Maintaining the school’s great ability in science and engineering, while presenting at the same time its aptitude in the arts, the sculpture will help to dispel the reputation WPI has earned as a strictly engineering based institute.

The full benefits of this project will not be realized however, unless the artwork is actually constructed. For this, it is suggested that a Major Qualifying Project be established with the goal of completing the integration of this art onto the WPI campus. This would most likely be offered in the school’s Civil Engineering Department, as the design still needs to be analyzed for its structural integrity, and its construction overseen by a group with some background in project management. If this can be done, and the project is successful, Concrete Jungle will prove an invaluable addition to the WPI campus for many years to come.
Appendix
A: Introduction

Oval with Points

http://www.kunsthalle_bielefeld.de/web_neu/seiten_en/draussen_04.html

Needle Tower

http://www.maa.org/mathland/needle.jpg
B: Environmental Art

Spiral Jetty
http://www.hawaii.edu/lruby/art400/sculpt.htm

Spoonbridge and Cherry
http://en.wikipedia.org/wiki/Spoon_Bridge_and_Cherry
Running Fence
http://christojeanneclaude.net/rf.html
C: Map of Potential Locations

1. Salisbury Labs Lawn
2. Skull Tomb
3. The WPI Main Entrance
4. Higgins House Gardens
5. Behind the Campus Center
D: Comments from John Miller

The following is a list of comments and suggestions from John Miller, Director of the Physical Plant at WPI, concerning the sites proposed as potential locations.

Salisbury Labs

- Most feasible
- Crying for artwork
- The walkway (West Street) serves as an access route for emergency services, and therefore would a clearance of at least 15 feet would need to be maintained

Skull Tomb

- The area is historic and, as such, should be preserved in its current state

Main Entrance to WPI

- The area is too close in proximity to a public roadway
- A modern sculpture would compete with the traditional look of nearby Alden Hall and the footbridge

Higgins House Gardens / Behind the Campus Center

- No immediate issues
E: Results of the myWPI Survey

<table>
<thead>
<tr>
<th>Response</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
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<td>Disagree</td>
<td>236</td>
</tr>
<tr>
<td>Indifferent</td>
<td>372</td>
</tr>
</tbody>
</table>
F: Campus Center Survey

WPI is known for its educational emphasis on science and engineering. The school does however recognize the importance of more artistic subject matter, although its display of such creations is very limited. Actions are currently being taken to change this.

The purpose of this survey is to examine how students and faculty of WPI would feel about such a change, and to gain and understanding exactly what kind of artwork they are looking for. We ask that you please complete this short survey (approx. 3 min.) so that we may be better able to represent the ideas and interests of the WPI community throughout the design process. Thank you!

I would like to see more outdoor artwork on the WPI campus.

1  2  3  4  5
Strongly Agree  Agree  No Opinion  Disagree  Strongly Disagree

Please rank each design according to which you would most like to see on campus (1 being your first choice, and 6 as your last).

A Closer Look ________ Like Clockwork ________
Perspective ________ Equilibrium ________
Concrete Jungle ________ Floating Blocks ________

Why did you choose this as your number 1?
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Where would you like to see your #1 constructed on campus? Please give us your top three choices (1 being your first choice, and three being your 3rd).

Location 1: In front of Salisbury Labs ________
Location 2: The area near Skull Tomb ________
Location 3: Institute Rd. entrance to WPI ________
Location 4: Higgins House Gardens ________
Location 5: Behind the Campus Center ________

Please provide any additional comments (likes, dislikes, necessary changes, etc.) on any of the designs.

A Closer Look: _________________________________________________________________
Perspective: _________________________________________________________________
Concrete Jungle: _______________________________________________________________
Like Clockwork: ______________________________________________________________
Equilibrium: ________________________________________________________________
Floating Blocks: ______________________________________________________________

Thank you again for taking the time to complete this survey. We look forward to reading your opinions!
**G: Results of the Campus Center Survey**

Question 1: I would like to see more outdoor artwork on campus.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>32</td>
</tr>
<tr>
<td>Agree</td>
<td>24</td>
</tr>
<tr>
<td>Indifferent</td>
<td>3</td>
</tr>
<tr>
<td>Disagree</td>
<td>0</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>0</td>
</tr>
</tbody>
</table>

Strongly Agree 55% (32/58)

Agree 41% (24/58)

Question 2: Please rank each design according to which you would most like to see on campus (1 being your first choice, and 6 as your last).

<table>
<thead>
<tr>
<th>Design</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Blank</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Closer Look</td>
<td>12</td>
<td>10</td>
<td>15</td>
<td>12</td>
<td>4</td>
<td>8</td>
<td>2</td>
<td>252</td>
</tr>
<tr>
<td>Perspective</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>11</td>
<td>21</td>
<td>6</td>
<td>3</td>
<td>198</td>
</tr>
<tr>
<td>Concrete Jungle</td>
<td>16</td>
<td>10</td>
<td>11</td>
<td>10</td>
<td>7</td>
<td>7</td>
<td>2</td>
<td>247</td>
</tr>
<tr>
<td>Like Clockwork</td>
<td>5</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>31</td>
<td>4</td>
<td>153</td>
</tr>
<tr>
<td>Equilibrium</td>
<td>5</td>
<td>12</td>
<td>14</td>
<td>14</td>
<td>11</td>
<td>3</td>
<td>4</td>
<td>219</td>
</tr>
<tr>
<td>Floating Blocks</td>
<td>17</td>
<td>13</td>
<td>7</td>
<td>8</td>
<td>11</td>
<td>4</td>
<td>3</td>
<td>251</td>
</tr>
</tbody>
</table>
Question 3: Where would you like to see your #1 constructed on campus? Please give us your top three choices (1 being your first choice, and three being your third).

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salisbury Labs Lawn</td>
<td>30</td>
<td>12</td>
<td>10</td>
<td>124</td>
</tr>
<tr>
<td>Skull Tomb</td>
<td>7</td>
<td>12</td>
<td>19</td>
<td>64</td>
</tr>
<tr>
<td>Main Entrance</td>
<td>8</td>
<td>19</td>
<td>8</td>
<td>70</td>
</tr>
<tr>
<td>Higgins House Gardens</td>
<td>0</td>
<td>4</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>Behind the Campus Center</td>
<td>15</td>
<td>10</td>
<td>11</td>
<td>76</td>
</tr>
</tbody>
</table>
Salisbury Labs Lawn, Skull Tomb, Main Entrance, Location, Higgins House Gardens, Behind the Campus Center

Score

Salisbury Labs Lawn 120
Skull Tomb 60
Main Entrance 70
Location
Higgins House Gardens 10
Behind the Campus Center 80
H: Survey Question 4 Results: Comments on Each Design

A Closer Look
- It is nice that it represents WPI
- Small enough to be feasible
- It shouldn’t market WPI
- It should be strong enough to climb on
- It is too hard to read the “WPI”
- Too abstract

Perspective
- Too complicated
- It is nice that it represents WPI
- It shouldn’t market WPI
- Simple and clear
- It should be strong enough to climb on
- This would look good at the entrance
- Aesthetically pleasing
- Will look good at full scale
- Visually creative

Concrete Jungle
- Should be mobile
- Too complicated
- The contrast between nature and man is a good idea
- This would be nice near skull tomb
- It doesn’t take up too much ground space
- This would look good in front of the environmental building
- It is functional, like a meeting place
- Very weird
- The colors are nice
- Subtle

Like Clockwork
- The clock is a good idea
- Hard to understand
- Model isn’t presentable
- Too cluttered

Equilibrium
- Looks dangerous to walk under
- Will not translate well to full scale
• Like the floating illusion
• Not aesthetically appealing
• Interesting to look at

**Floating Blocks**

• Very aesthetic
• The concept of ascent s a good idea
• Too simple
• Will not translate well to full scale
• Change it to WPI colors
• Straightforward design
• Interesting design
• The shapes are too sharp aesthetically
• The cables should be as invisible as possible
• It is good that it does not say “WPI”
I: The Campus Center Experience

On Friday, January 26th, our IQP group completed a survey in the Campus Center to gain feedback on several topics regarding our project. The survey spanned from 9:00am until 3:00pm, and in that time period sixty-three surveys were completed fully, and although not all students filled out a survey, they verbally offered their input, which was recorded in addition to the survey. At the table, we had several visual representations of our project; we displayed each of our individual models, complete with a brief description of each design to help people visualize what the respective creators had in mind more clearly. In addition to our models, we had different colored concrete samples the students could look at to better visualize what the final sculpture would look like, as well as a poster with pictures of the proposed sculpture locations. With these materials, we hoped the students’ ability and willingness to complete our survey would increase, and help us to gain a larger audience. This would in turn create a more diverse demographic in our survey results, creating a more accurate representation of what type of sculpture the student body would want to see on campus.

The most noticeable thing we observed from the Campus Center survey was the varying interest in participation among the students that approached our table. A majority of the students would briefly look over the models and poster with the locations and fill out the survey. These students would most often only fill out the circle or numbering portions of the survey, and fail to write any comments or addition suggestions they may have. On the other end of the spectrum, a few students spent a lot of time at our table, closely studying the models and concrete samples, asking several questions about the designs and the project as a whole. These students most often filled out the survey completely, adding several lengthy comments with suggestions and
feedback to our designs and offering other possible locations not presented in the survey. A handful of students spent upwards of one half hour studying the models and asking questions before filling out the survey. These responses proved to be the most helpful when conducting results analysis after the survey, as they not only offered opinions on topics we asked about, they often times offered insight to possibilities and ideas the group had not previously thought of.

The comments and responses of the students ranged anywhere from expressing great excitement to the idea of having more artwork on campus to concern that the proposed designs could be potentially hazardous and propose a risk to the students walking underneath. The spectrum of reactions and thoughts was extremely diverse, and we made note of any comments and concerns the students may have expressed, whether it was in writing or verbally. Upon gathering all the results from the survey, we compiled the responses and created results tables to examine and help us to determine what courses of action we should take, and which options to further expand on.

After conducting the Campus Center survey, we used the suggestions and comments, in addition to the survey results, to help guide us in making decisions leading to the final design selection and location proposal. After analyzing the results from the survey, we were able to narrow the potential final design down to three candidates; Floating Blocks, Floating WPI and Concrete Jungle. In addition, the students had an overwhelming showing of approval of putting the sculpture in front of Salisbury Labs, which coincidentally happened to be the favored location of the group. After completing a pro versus con chart comparing and contrasting the three designs, Floating Blocks was ruled out as an immediate first choice, as its costs and inherent complications far outweighed its merits. In closing, the Campus Center survey turned
out to be a great success, and its results were highly beneficial to continuing the project, aiding us in decision making throughout the entire process.
### J: Pros and Cons of the Final Three Design Concepts

**Floating WPI**

**Pros**
- Represents WPI
- The most inexpensive concept
- Size is flexible (can be large or small scale)
- Could be placed in one of several locations
- Fits campus style

**Cons**
- Difficult to see the W-P-I
- Represents WPI

**Concrete Jungle**

**Pros**
- Man made material reflecting nature
- Does not require much ground area
- Fits campus style

**Cons**
- Difficult to construct
- Possible liabilities

**Floating Blocks**

**Pros**
- More impressive than the current fountain
- Colors could represent WPI

**Cons**
- Difficult to construct
- Possible liabilities
- Does not fit the campus style
- Fountains could not operate year round
- Requires a lot of ground area
- Highest maintenance costs
K: Cost Analysis

1. 12” reinforced concrete pipe
   Price:
   - Material: 9.27/lf
   - Labor: 8.48/lf
   - Equipment: .79/lf
   - Total: 18.54/lf
   Required amount:
   - Average length: 6 ft
   - Quantity: 18
   - Total: 108 lf
   Cost:
   - Material: $1001.16
   - Labor: $915.84
   - Equipment: $85.32
   - Total: $2002.32

2. 18” round structural reinforced concrete column
   Price:
   - Material: 99.50/cy
   - Labor: 48.50/cy
   - Equipment: 15.00/cy
   - Total: 163.00/cy
   Required Amount:
   - Height: 15 ft
   - Volume: 1.0 cy
   Cost:
   - Material: $99.50/cy
   - Labor: $48.50/cy
   - Equipment: $15.00/cy
   - Total: $163.00/cy

3. Footing Excavation
   Price:
   - Labor: 68.00/cy
   - Equipment: .42/cy
   - Total: 68.42/cy
   Required Amount:
   - Volume: 2 cy
   Cost:
   - Labor: $136.00
   - Equipment: $0.84
   - Total: $136.84
4. Concrete Footing
   Price:
   Material: 99.50/cy
   Labor: 28.70/cy
   Equipment: 8.90/cy
   Total: 137.10/cy
   Amount Required:
   Volume: 2 cy
   Cost:
   Material: $199.00/cy
   Labor: $57.40/cy
   Equipment: $17.80/cy
   Total: 274.20/cy

5. Wire Rope
   Price:
   Material: 1.59/lf
   Labor: .46/lf
   Total: 2.05/lf
   Amount Required:
   Average length: 5 ft
   Quantity: 48
   Total: 240 lf
   Cost:
   Material: $381.60
   Labor: $110.40
   Total: $492.00

6. Wire Rope Clips
   Price:
   Material: 3.90 ea
   Labor: 2.58 ea
   Equipment: 0.03 ea
   Total: 6.51 ea
   Amount Required:
   Total: 96
   Cost:
   Material: $374.40
   Labor: $247.68
   Equipment: $2.88
   Total: $624.96

7. Wire Rope Thimbles
   Price:
   Material: 10.20 ea
Labor: 15.90 ea  
Equipment: .17 ea  
Total: 26.27 ea  

Amount Required:  
Total: 96  

Cost:  
Material: $979.20  
Labor: $1526.4  
Equipment: $16.32  
Total: $2521.92  

8. Assembly  
Price:  
Labor: 30.00/hr  
Amount Required:  
Total: 64 hours  
Cost:  
Labor: $1920.00  

9. Erection  
Price:  
Labor: 30.00/hr  
Equipment: 203.50 for 20’ chain hoist  
Amount Required:  
Total: 32 hours  
Cost:  
Labor: $960.00  
Equipment: $203.50  
Total: $1163.50  

Sum of Above Costs: $9298.74  
Including 25% Contingency:  
Total Cost: $11,623.40  

Final Cost Estimate:  
$11,700.00
L: Information Packet for Meeting with Major Gifts Office

Concrete Sculpture Design
Matthew Fuhrmeister
Katie Nehmer
Joe Sinagra
Kyle Kappmeyer
Mike Fecteau
Matt Caulkins
Overview:

The six members of this group are part of an IQP with the focus of designing a sculpture that would be erected on campus as an MQP in the near future. Considering the noticeable lack of artwork on campus, a significant sculpture is an essential addition to WPI’s scenery. A piece like this will make a statement about the college’s flair for the arts; a perfect compliment to the solid foundation of science and technology.

Details:

This sculpture is based on a concept called tensegrity, developed by artist Kenneth Snelson. Each member is suspended by wires to seem as if it is floating in the air. The members are designed to work together to reach a complex static equilibrium. This piece will be constructed of colored concrete that is suspended by steel cables. It would stand 15 feet tall in front of Salisbury hall, in the grass next to the walkway.

This school has one of the most historic and beautiful campuses in the area. The most important goal in the design of a sculpture should be to not detract from that beauty. The proposed work will provide accent the natural appeal of the area perfectly, while presenting a stimulating and artistic facet. This sculpture is designed to be an abstraction of a tree, consisting of a brown concrete trunk, and green concrete cylinders floating above it. The juxtaposition of the manmade construction materials of the sculpture to the natural and living essence of a tree parallels the contrast between the technical subjects of the college and its gorgeous natural setting. It evokes the often unnoticed liberal side of WPI.

The total cost of material, equipment, and labor for this sculpture is estimated to be $11,700.
Campus Reaction:

A survey was taken to obtain a sense of the reactions of other students to artwork. Of those surveyed, 95% agreed that there should be more outdoor artwork on campus, overwhelming support for a project such as this. For the survey, six possible options for a sculpture were presented. The sculpture described above was well received and highly voted by the students, and eventually chosen as the best option for WPI. The location (in front of Salisbury Hall) was the top choice for location of those surveyed.

Funding and Construction:

The result of this IQP should be full approval of WPI to complete this project, as well as a full proposal and the means to find adequate funding for the construction. Construction of this sculpture would be carried out by contracted companies, hired and overseen by an MQP group in the future.

Contact:

The group can be contacted by email at sculpture@wpi.edu.

Campus Center Survey Results:
**Complete Cost Analysis:**

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   **Price:**
   - Material: 9.27/lf
   - Labor: 8.48/lf
   - Equipment: .79/lf
   - Total: 18.54/lf

   **Required amount:**
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$11,700.00
Concrete Sculpture

IQP

Matthew Caulkins
Michael Fecteau
Matthew Fuhrmeister
Kyle Kappmeyer
Kathleen Nehmer
Joseph Sinagra

Advisor: Tahar El-Korchi
Co-Advisor: Brigitte Servatius
Overview

Worcester Polytechnic Institute, while known for its excellence in engineering and life sciences, often falls short in its representation of the arts. The six members of this group are part of an IQP with the focus of designing a sculpture which would display the students’ artistic aptitude in such a way as to highlight the University’s strengths in mathematics and engineering.

Designs

Our proposal is a large-scale sculpture, constructed from colored concrete and steel cables, that utilizes the mathematical concept of tensegrity, first established as an artistic practice by Kenneth Snelson. Tensegrity is a principle of structural engineering in which each member is held in perfect balance by the tension and compression forces acting upon it. This makes the concrete elements appear as if they are floating in mid-air.

The sculpture we have designed was chosen from models of many other designs that were considered. The final selection is shown in the attached picture and stands 15 feet tall and 10 feet wide. It is composed of a concrete column that supports three branches of concrete tensegrity formations. The members are suspended in such a way that none of them come in contact with each other, and they seem to float.

The sculpture is an abstract representation of a tree, formed from a brown concrete trunk and green concrete branches. The branches will even sway in the wind, as a tree would. The artwork juxtaposes the man-made construction materials from which it is made with the natural and ecological formation that it depicts. This presents the balance between engineering and nature that students of a technical school must observe. It is not only a marvel of engineering, but also a beautiful symbol of Worcester Polytechnic Institute’s artistic value.

Locations

Following consideration of a number of possible locations, the one chosen for the artwork was the lawn in front of Salisbury Labs and adjacent to West Street, the central walkway through campus. This site is easily viewed and accessible to the campus community, but also provides sufficient open space to accommodate such a large sculpture. This location was suggested by John Miller, Director of Plant Services, as one of the most feasible spots on campus for artwork to be placed.

Survey

To ensure that the proposed structure was in the best interest of the University, it was essential to gather the input of students and faculty on the subject. In order to do this, two surveys were conducted. The first was a brief poll distributed on MyWPI, to determine if there was a desire for more outdoor artwork on campus. The survey was posted for two weeks, and nearly 1,500 students and faculty responded with overwhelming support for additional artwork.
The second survey conducted endeavored to obtain a more comprehensive and detailed account of student opinion on the design and location. It was conducted interactively in the Campus Center, so that the participant’s input would be most useful. The students were presented with multiple design models, photographs of possible locations, and colored concrete samples, and asked to choose which appealed to them most. The results of the survey supported the location and design described above, and reaffirmed the enthusiasm for new artwork on campus.
N: Poster for Presentation to President Berkey

WPI Concrete Sculpture

Interactive Qualifying Project

Sculpture by Calatrava

Snelson’s “Rainbow Arch” (2001)

Would you like to see more outdoor art work on Campus?

Project Members: Matthew Caulkins, Michael Fecteau, Matthew Fuhrmeister, Kyle Kappmeyer, Kathleen Nehmer, Joseph Sinagra

Project Advisors: Professor Tahar El-Korchi, Professor Brigitte Servatius
Bibliography

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