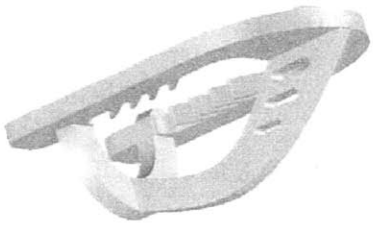
The Back Stroke Buddy



by

Gregory Paul Fonder

Submitted to the Department of
Mechanical Engineering in Partial Fulfillment of
the Requirements for the Degree of

Bachelor of Science

at the

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ABSTRACT

The objective of this thesis was to study and improve one's own physical intelligence. Through studying bodily movements of people trying to accomplish new tasks, I realized one way to enhance physical intelligence was through teaching devices. My area of expertise in training was swim instruction, as I have been teaching swim lessons for over seven years. The initial problems that new swimmers encounter involve getting accustom to the water, submerging their heads, and floating on their backs. As a swim teacher, one can verbally instruct students through the first two problem areas, but in order to float on one's back, there are methods required to facilitate this skill. The most widely used approach is for a swim teacher to support the back of the student's head and neck with his/her hand and guide the student through the water. The goal of this thesis is to eliminate the need for constant support from a swimming teacher by developing a device which will apply the same teaching technique, yet enable students to learn using this device to swim on their backs without assistance.

The apparatus created by following the criteria set forth is aptly named *The Back Stroke Buddy*. This apparatus consists of three parts - a head support, a neck support, and a base. A swimmer's head will lie in the middle of the base while the head and neck support, which are located below the base, cradle the back of the head and provide support. This device is made out of soft foam which allows it to be robust and one size fits all. While it does meet all the necessary requirements set forth, *The Back Stroke Buddy* does have other added benefits. This device, due to its durable nature, allows the user to swim into an obstacle such as the wall or a lane line while remaining unscathed. Although this device does enable the swimmer to float on his/her back, the strokes which can be performed while using it are limited because of shoulder interference.

Future work on this product involves making *The Back Stroke Buddy* more conducive to all arm movements, obtaining a patent and producing it large scale to be sold in stores.

Thesis Supervisor: Alexander H. Slocum
Title: Professor of Mechanical Engineering

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1.0 Introduction

The Back Stroke Buddy has gone through numerous additions and modifications before reaching its final design. It began as a simple kickboard, but over time evolved into an affordable teaching and safety device useful to people of all different sizes. Throughout the design process, this product has undergone many adjustments before reaching its present, finished form. It is important to understand the thought process involved in developing the concept behind *The Back Stroke Buddy*. Without these preliminary steps, this assistive learning device would never have been created. This section will cover my personal relation to this apparatus and how the benefits achieved will directly affect my life. Next, I will discuss the initial and evolved goals of this product, including how it relates to the seminar which essentially encouraged the development of such an indispensable teaching aid. Then, finally, the marketability of such a product will be addressed.

1.1 Background

Throughout my life, my three passionate interests have always been family, school and sports. As I think back now, at no point in my life have I ever abandoned any of these themes so it is no wonder they are still influencing my present areas of commitment. When it was necessary to choose a thesis topic, I investigated numerous laboratory projects which, although meeting the necessary requirements, would not have encouraged the additional amount of effort I devoted to developing this idea simply out of personal interest. While still searching for a thesis topic as the semester was about to start, I became aware of the class Physical Education for Mechanical Engineers (SP.250- PE for ME), a seminar that was attached to undergraduate mechanical engineering theses. At the information session for this class, the one topic that was stressed to the students was the importance of relating physical intelligence to our theses projects. It was this requirement specifically that encouraged the development of an athletic device which piqued my interest and garnered my enthusiastic support.

As the class began, I had reservations about my decision to enroll in this seminar. For three hours on the first day of class we simply talked about the concepts surrounding exercise and then toured the MIT Zesiger Sports and Fitness Center. As an athlete throughout my whole life, I speculated why it was necessary to participate in such a basic exercise. The following class seemed even more absurd to me; we actually played with elastic bands and tied them to each other with the purpose of making "new exercise equipment." At this point, I was prepared to start looking for an alternate route. A thesis project is very important and I was fearful that this class was not supporting the goal I originally had planned to achieve. For week three, the professor required three ideas for our thesis project, yet, in reality, we had not addressed anything related to picking thesis topics. The expectation was to present three concepts with only a week preparation. Finding new and innovative exercise equipment was challenging but I managed to sketch three ideas to bring to the next class.

During this third class I realized how my history as an athlete prejudiced my project ideas. Two of my three concepts were for single degree of freedom weight lifting equipment which were particular to my needs. At this juncture I recognized that my perspective regarding the class needed to change; rather than criticizing the class exercises I needed to be more open to them and take advantage of the underlying principles that were being addressed. With this in mind, I took the exercise in the third class more seriously. This lesson concerned the techniques of assisting the human body with new movements it had to master. As an adult learner, I appreciated the concept and realized that this was a thought provoking problem. As a class, we attempted various tasks while blindfolded and then discussed all the reoccurring emotions and fears that, as 21 year old seniors, we have not experienced in a long time. This sensation of fear and thrill reminded me of when I learned new activities as a child, such as the first time I rode my bicycle, plunged into deep water, or flew through the air while pole-vaulting. Each of these events involved a new motion and environment that my body had not previously experienced. After this class' exercise, I came to the realization that my third concept drawing involved a teaching device for the pool which would assist new swimmers in this new environment and meet the criteria for the senior thesis.

This session reaffirmed that education is an interactive experience and that there is an underlying rationale for each topic presented. Because of my new open approach to this class I was able to develop my third concept drawing into a project fulfilling my thesis. The proposal was to design a device that would assist swimmers in developing the skill of floating in water in the supine position. (Appendix A) This not only met the class requirements but was a challenging project to develop and design. For the next class, I presented a rough draft thesis proposal with a sketched model that emerged as barely effective. Yet, when the professor and the class reviewed the proposal, the prototype was eagerly accepted. The encouragement of my professor and peers, along with my personal aspiration as an engineer, promoted my drive to develop a superior piece of equipment, *The Back Stroke Buddy*.

1.1a Personal Experience

This proposal's original concept was closely associated with my life. For me, learning, practicing and competing in sports has always been one of my passions but, in addition, so has sharing and teaching my skills to others. My entire life I have always been teaching my little brother, who is three years younger, anything new I learned in school or during extracurricular activities. These experiences were always rewarding and prepared me to expand this expertise to other areas when the opportunity presented itself. As I entered high school, I began to understand that I got a sense of personal satisfaction by helping others whether through volunteering with boy scouts, tutoring fellow students or teaching swim lessons at the local pools. I always took pride in assuring that each person I assisted received my full attention and that I did the best job possible.

When I volunteered, I provided the necessary time and commitment to make sure that no job was left unfinished. Tutoring was provided individually so that I could offer my

undivided attention to each student. Swimming, however, is ordinarily taught in group lessons of four to ten swimmers so that individualized attention is rare. For the more experienced swimmers who only require stroke technique assistance, these lesson sizes are optimal. For younger or more inexperienced swimmers who require personal attention and support, these larger classes allow only limited time for introduction of new skills during the session. As a swim instructor, the most difficult skill to teach in a group setting is the supine or back floating technique. The inexperienced swimmer is not accustomed to the supine position, the different motion experience and the splashes of water on their unprotected face and airway. These all create an uncomfortable sensation so often that the student will instinctively turn over to the prone position. As a swimming teacher, it is necessary to support each swimmer's entire body until they are at ease floating on their backs while in the water. The next stage is to support each student's head and neck while guiding them across the pool until they are secure enough to perform this skill without assistance. Completing this instructional process varies with each swimmer and may require anywhere from two minutes to several weeks for proficiency.

The idea for *The Back Stroke Buddy* developed from the dilemma: how does a swim instructor teach group lessons and have all the students practicing their skills at the same time? *The Back Stroke Buddy* was my solution. I had contemplated the premise, what if there was a device that would replace the need for constant support by a swim teacher and allow students the opportunity to safely practice supine floating independently. This apparatus would permit freedom to the swim instructor to assist each student with his/her technique while the rest of the class could continue to practice independently. This would enhance the time of actual instruction and practice during each swim lesson session. I surmised that this device would have to meet the requirements of comfort, safety, one size fits all and most importantly functionality.

1.2 Objectives

As inferred from its name, *The Back Stroke Buddy,* the goal of this device is to assist beginner and novice swimmers with supine swimming strokes. While becoming proficient in the skill of floating or swimming on one's back, many issues arise that can stimulate fear in a student. While being on their backs in the water, these problems for the swimmer include water splashing on the face which may interfere with breathing and the head bumping into objects such as the pool wall, lane lines or other swimmers. To help students learn to swim on their back, this device will eliminate these nuisances. To accomplish this task, *The Back Stroke Buddy* will:

- keep the intended swimmer's head high enough out of the water to minimize splashing onto the face
- provide protection to the swimmer's head from obstacles such as lane lines, walls and other swimmers
- keep the swimmer's head looking straight up to teach the swimmer proper backstroke positioning.

The Back Stroke Buddy will assist with these skills and will not interfere with one's stroke. This apparatus will facilitate an individual's safety and comfort while practicing

supine swimming whether s/he is first learning how to swim or is an experienced swimmer.

The Back Stroke Buddy must be designed to meet many requirements and needs to be evaluated during actual group swim lessons and by individual independent novice swimmers. The information acquired from a proficient swimmer will not necessarily coincide with the suggestions from a new swimmer so both are necessary. Students who have never floated on their back before will be asked to test this device all the while being closely observed for safety and issues in utilizing this device properly and efficiently. From this observation, I will be able to determine if this device really makes a difference in instructional swimming. The expectation is that the beginner swimmer will not become instantaneously proficient while swimming on his/her back but will be able to independently, safely and comfortably swim around the pool. If a new swimmer can successfully accomplish this task and *The Back Stroke Buddy* assisted in this skill development, I will know the effectiveness of this project.

1.3 Physical Intelligence Dimension

As mentioned in Section 1.1, my senior thesis has been combined with the seminar PE for ME. Although the eventual outcome of this seminar was to invent a new sports product, part of my thesis' inspiration and uniqueness came from the seminar's collaboration and integration. The seminar's principal objective has been realized by my thesis' transformation from a purely cross training and body building device into a teaching device. Although I would have been content designing new lifting machines and practicing an obscure one degree of freedom motion, realistically this project would not have the opportunity to influence as many people and may not have been useful at all. *The Back Stoke Buddy's* benefits come from its assistance in teaching a skill to swimmers, allowing independent practice, and promoting the efficacy of group lessons. Not only is this proficiency essential to all swimmers, this device assists in the instruction of a swimmer in new ways of propelling themselves across the pool, thus enhancing their physical intelligence when moving through any body of water.

2.0 Apparatus

This portion of the report is devoted entirely to *The Back Stroke Buddy's* evolution from ideas and concepts into a final marketable product. While it is not unusual for a product to take weeks and/or months to develop into preliminary sketches for the model stages, the building and testing for this product actually monopolized most of the available time in this one semester project. Due to uncertainty with regards to both its initial objectives and the available quality materials, mock-up testing had to be done early so the proper final materials could be purchased.

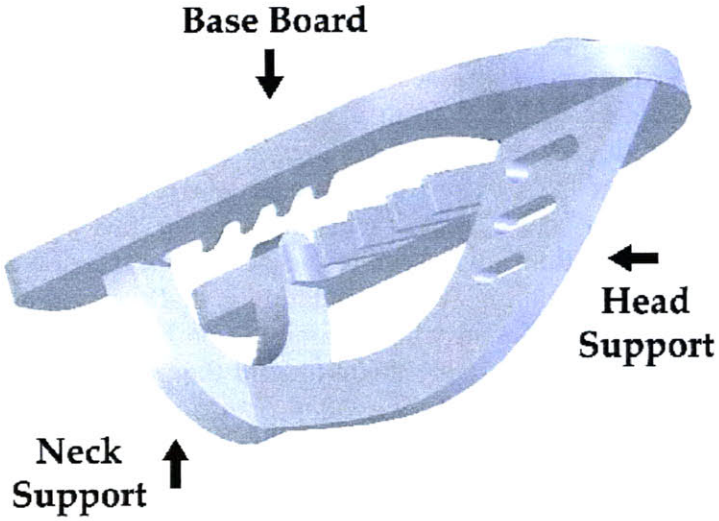


Figure 1: Generic 3-D version of *The Back Stroke Buddy* with its three main components labeled.

In order to understand the developmental process of *The Back Stroke Buddy* some key terminology is necessary. Although the three components of this device vary in shape, size and material, throughout this section their purposes remain the same. The base board is the building block from which this product can be realized. Not only does it provide stability for the device, but in sketch models 7, 8 and 9 it also centers the user's head. The neck support has been changed the least over the evolution of this apparatus, yet it is most central to the effective functioning of this teaching device. The head support was initially elastic straps and evolved to a foam structure as its functionality increased from solely support to protection as well. Section 2.1a will depict the developmental phases of *The Back Stroke Buddy* but will not be overloaded with precise dimensions of the apparatus. Section 2.2, along with Appendix B, will provide the necessary details for the final design.

Figure 2: *The Back Stroke Buddy* in use.

2.1 Thought/Design Process

This section will discuss the transformation of an ordinary kickboard into *The Back Stroke Buddy*. A kickboard was chosen as the basis for design for two reasons: it is the most widely used piece of pool training equipment and it was the only material readily available for sketch model use. These two factors were not limiting in nature but provided a starting point for this project. Choosing to use such an inexpensive, easily obtained, widespread material proved to be beneficial because the number of sketch models was therefore not limited by funds. The amount of consideration and planning that went into each sketch model's design, although quite useful when mapping new designs, could not compare to the wealth of information gained from experimenting with the device in a pool. After each modification there were noticeable improvements but as the apparatus developed into a working and comfortable device, its objectives were expanded to bypass its initial aspirations. In total, nine sketch models were created; each modification being for a specific purpose and allowing for insight to be gained on why or why not the adjustment worked. Even more importantly, this showed how each of these changes affected the transformed kickboard's overall functionality. For a timeline of each sketch model's testing date, see Appendix C.

2.1a Sketch Models

Each sketch model was cut from a standard 1¼" X 11½" X 17" kickboard. (Appendix D: Section 1) There are various degrees of stiffness associated with the different kickboard colors and they will be mentioned as deemed appropriate. Subjects mentioned in the sketch model summaries consisted primarily of the participants in the Physical Education for Mechanical Engineers class (SP.250) which had an enrollment of seven students and three professors.

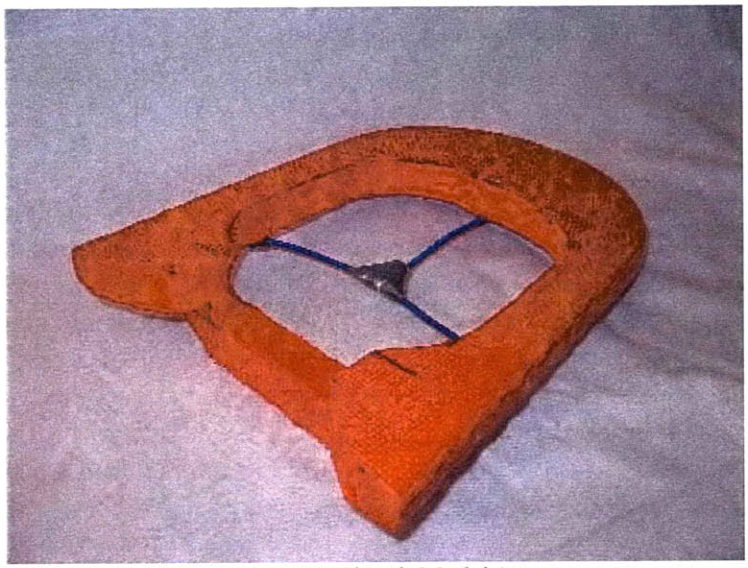


Figure 3: Sketch Model 1.

Sketch Model 1

The first sketch model's function was to demonstrate the physical possibility of realizing the eventual goal of the final product: to support one's head and neck in water without outside assistance. To accomplish this task, some very rigid kickboards were cut to specified dimensions and assembled as seen in Figure 3. The model's components consist of a large base board as the underlying structural support, a depressed neck support, and straps to support the back of the swimmer's head. This first model had several major drawbacks: it was not comfortable, it wobbled around behind the head, and it scratched the ears and neck. Despite these negative aspects, the device did support every subject's head and neck enough to keep their faces out of the water and leave their breathing airways splash free. Although this design looks quite crude, its simplicity allowed for easy construction of the next sketch model.

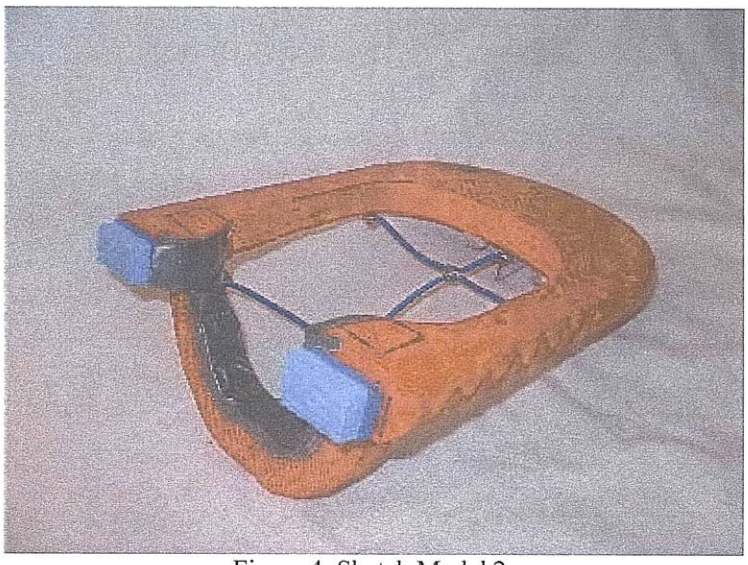


Figure 4: Sketch Model 2.

Sketch Model 2

This model's objective was to keep the same functionality as the first sketch model while making the overall experience of wearing this device more pleasant. The base board was kept the same size as in the previous model but the back edges, where the base board meets the shoulders, were replaced with softer padding. The neck support was lowered from the previous model to allow the neck and head to lie deeper in the device while maintaining the ears approximately at the level of the base board. The duct-tape around the neck support was utilized to smooth the edges and eliminate accidental scratching of the swimmer. The head straps were moved lower and the locations on the intersections between straps were moved to spots were they would not contact one's head. This mock-up was more efficient and comfortable than the first because of the depressed neck support. This feature allowed the head and neck to be lifted out of the water enough to keep the face dry while not bending the neck back. The head straps, although more comfortable, still allowed the head to tilt to either side causing the swimmer's ears and head to rub again the rigid base board. The duct-tape on the neck did eliminate scratching

on the neck and was a temporary solution for the sketch models with the plan of sanding every edge for the final mock-up model. Finally, the shoulder pads were not useful because the swimmer could not notice them. They were an unnecessary addition.

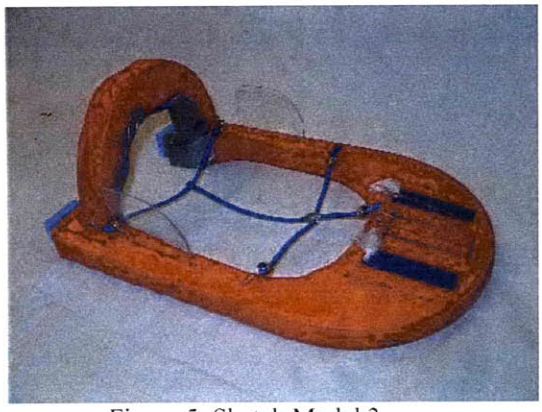


Figure 5: Sketch Model 3, pictured upside down for viewing purposes.

Figure 6: Close up of fin on Sketch Model 3.

Sketch Model 3

This design's purpose was primarily to try eliminating the major problem from the second sketch model in which the swimmer's head would fall to either side of the center strap and consequently be pushed and rubbed into either side of the base board. One possible way to solve this dilemma was by adding fins to the bottom side of the base board. (Appendix D: Section 2) Nine Plexiglas fins were designed; each being 3 inches long but varying in height: 1, 2, or 3 inches. Multiple combinations were tested using seven different possible fin locations in the base board. The optimal experimental setup was to have a 1 inch fin in the front center and 2 inch fins next to each ear, as seen in Figure 5. This setup maintained the device so it was pressed against the swimmer's shoulders and therefore, as long as his/her neck was kept straight, the head would remain in the middle of the base board not hitting either side.

The fin combinations were established by experimentally eliminating many of the possibilities thus reducing the model testing time. Having the fins next to the neck support was too close to the shoulders consequently hitting them as the swimmer moved through the water; this eliminated two potential locations for the fins. By placing a fin at the front of the kickboard, or two towards the front equal distance from the middle of the base board, proved to dominate the motion of the kickboard and caused the swimmer to have limited control over directionality. After trying many combinations, anything larger than a 1 inch fin at the front center or two 1 inch fins equidistant from midline at the front of the apparatus would result in water turbulence causing the device to change direction and the front fin(s) applying torque to the swimmer's neck. This observation helped reduce these three slots at the front of the kickboard down to only three possible combinations: 1 inch fin in the middle, two 1 inch fins spread out, or no fins at all. The final two fin slots were next to each ear. Using symmetry, each side had to have the same size fin which eliminated three quarters of the possibilities leaving only four options:

either 1 inch, 2 inch, or 3 inch fins on either side or no fins at all. Trying these twelve combinations lead to an optimal arrangement.

The fins eliminated the head movement problem but, a possible new function of this device was brought into question; can this apparatus prevent swimmers from bumping their heads on obstacles present in the water such as the lane lines, other swimmers or pool walls? This device's base board surrounds the head and does protect it from floating obstacles, the lane lines and other swimmers, but could allow obstacles like the wall to pass underneath it. The design of the front fin was ineffective in preventing the swimmer from striking the pool wall and therefore the individual's head was not fully protected. While this protection element is a secondary function for this project, it was deemed important enough to abandon the fin idea, find a suitable solution to this problem, then come back and revisit the stability issues.

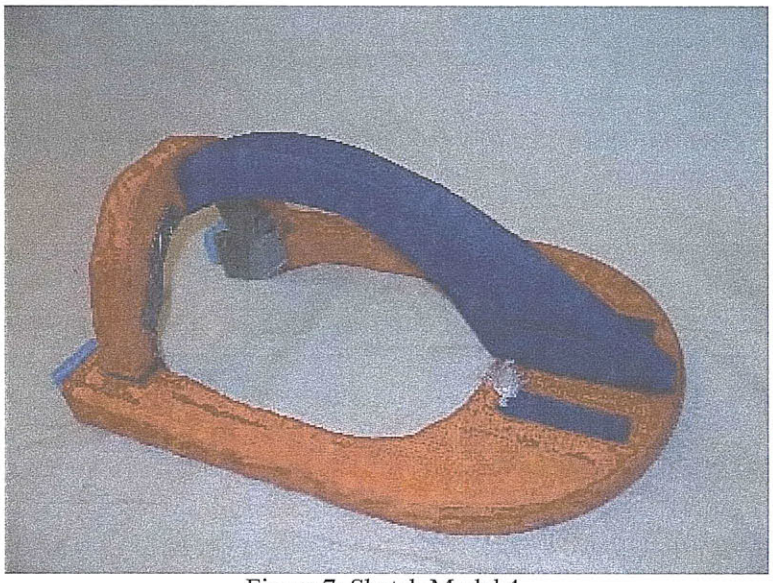


Figure 7: Sketch Model 4,
pictured upside down for viewing purposes.

Sketch Model 4

This model's goal was to protect the user's head from any obstacle that may be present in a pool. The base board and neck support are the same as in Sketch Model 3 but instead of having an elastic head support, a rigid head support was added. (Appendix D: Section 2) This rigid head support is made to keep the head at the center of buoyancy and protect it from any obstruction in the pool. The base board protects the swimmer from all pool objects and when contact with a wall is made, the head support gently glides up the wall protecting the swimmer's head and alerting the individual that they have reached the pool wall. While this new head support did protect one's head quite well, new problems were identified. The two major issues were that the head support, because it is constructed of foam, made the front of the kickboard too buoyant and the second problem was, as in all the previous sketch models, the head still hits and scratches on both sides of the base board.

To counteract the buoyancy issue, small weights were added to the front of the kickboard. While this solved the problem when using the device in the water, the apparatus becomes needlessly heavy when out of the water. A design to be considered in the future was the elimination of the weights and a proposal to remove some of the buoyant material, thus creating the same effect. For the stability issue, fins were added in multiple combinations in all the slots around the kickboard and none offered any positive effects. Based on what was learned in Sketch Model 3, the solid head support actually behaved like a large front fin making the system inherently unstable and adding more fins could not correct the instability.

Figure 8: Sketch Model 5,
pictured upside down for viewing purposes.

Sketch Model 5

Since the last model proved the effectiveness of the head support as a protective agent, the stability was now the most significant issue. This model, although made from a different kickboard, kept the same base board and neck and head support shape. The added component on this model is side elastic straps for stabilizing the head. These straps were designed to stay just below the ears and keep the head centered. While leaning back on this model in the water, the head rested in the middle and did not wobble at all. Plus, simply by picking up one's head the device slid right off of the swimmer. This device's design supported the head and neck, protected the head from obstacles in the water, and was a comfortable fit on a variety of head and neck sizes. The only problem that still existed was that the device was still too buoyant at the front causing it to eventually slide off one's head.

After testing this model, the part of the base board that comes in contact with the swimmer's shoulders was reduced in size to allow for a more full range of arm movements. While this effort did increase the range of motion of the swimmer's arms; the traditional backstroke still could not be performed. The next models of the device

(Sketch Models 7 and 8) were designed via Solid Works so more intricate patterns for the apparatus could be created to allow for backstroke to be executed.

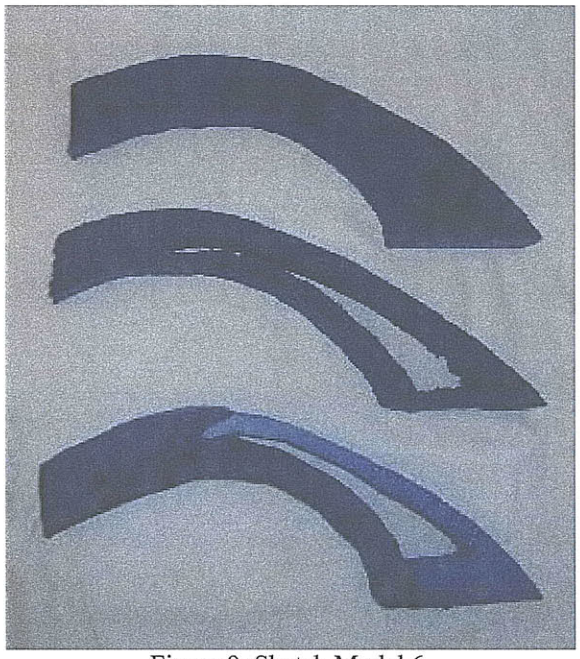


Figure 9: Sketch Model 6,
different prototypes for the head support.

Sketch Model 6

The final issue to solve was the buoyancy of the front of the kick board. To eliminate this problem the first proposal was to remove the center of the head support. (Figure 9, second from the top) This should allow for all the same benefits as seen in Sketch Model 5 while eliminating the buoyancy issue. When replacing the head support from Sketch Model 5 with this one, it did solve the buoyancy issue but on impact with the wall, it collapsed leaving the head to absorb the brunt of the impact. To remedy this issue, a more rigid piece of foam was added to the front of the head support while still allowing for the middle to be hollowed out. (Figure 9, third from the top) This worked perfectly but after a few trials the stiff front support became weak and again eventually left the head to absorb the brunt of the impact.

To solve this structural issue, horizontal slits in the head support were added to allow for material to be removed decreasing the buoyancy but not affecting the head supports impact strength. Although this was not tested due to lack of available materials, this structural technique is widely utilized in engineering and was deemed an acceptable solution. An example of this can be seen in Figure 10 which presents this concept on the following sketch model.

Figure 10: Sketch Model 7,
pictured upside down for viewing purposes.

Sketch Model 7

Due to a lack of supplies, extra time was available to create this sketch model. The model was built on SolidWorks and each piece was cut using a water jet. The kickboards used for the following three sketch models were much softer than previously used materials. This softer foam allowed for added functionality. (Appendix D, Section 1) These pieces, unlike the previous six sketch model components, were designed so that assembly is achieved by snapping them together. These snap together pieces will be further described in Section 2.1b. The head support was simply a continuation of what was planned for the final stages of Sketch Model 6 and the neck support is the same design that has been used in Sketch Models 2 through 6. The base board underwent a major transformation in this model. The outlying design was unchanged but this new base board was designed to eliminate the need for elastic straps and provide the required stability. To do so, fins were added along the sides of the base board to gently keep the swimmer's head centered. (Appendix D, Section 2) By utilizing these fins, the number of separate components in this device drops to three.

This model performed as expected and was better than all the previous models. This design met all the requirements and remained as one size fits all. After structuring the design of *The Backstroke Buddy* to three components that could snap fit together via SolidWorks, an actual potential for a marketable product was clear. A technology disclosure form was submitted prior to testing and experimenting with the apparatus because with this new three component concept, plans for eventually obtaining a patent became a reality. (Appendix E)

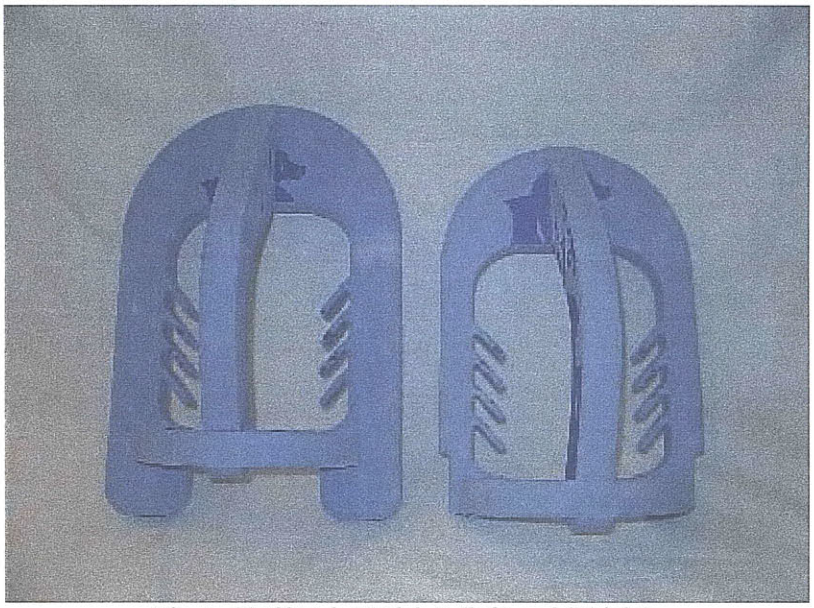


Figure 11: Sketch Models 7 (left) and 8 (right),
pictured upside down for viewing purposes.

Sketch Model 8

When Sketch Model 7 was only available via Solid Works, a second base design was created to be tested in conjunction with it. These base boards pictured above in Figure 11 have the same interior design yet radically different exteriors. Sketch Model 7 has the generic base board while Sketch Model 8 has incorporated the potential for being less restrictive on the motions for the arms and shoulders. Since much of the foam from the base board that would normally touch the shoulders was removed, the entire outer border was also reduced to balance out the buoyancy of the device.

Upon trying the device, it fit quite comfortably and allowed for a wide range of arm movements. However, there were issues with the stability of the device. Since the base board sides have had their thicknesses substantially reduced, the foam fins no longer kept the head centered. Without the stability that Sketch Model 7 provided, the extra arm range was determined to be less crucial than the stability. While observing another swimmer utilizing this device, the problem area was identified and future design changes could be incorporated, time permitting. Bending of the base board occurred above the stability fins where the sides attach to the large semi-circle front. The base board area below the fins was thinner but the sides were kept from bowing out due to the neck support.

Figure 12: Sketch Models 9.

Sketch Model 9

The goal of this model was a final attempt at designing a device that met all the requirements set forth through the planning and design process, while also accommodating a fuller range of arm motion. The head and neck support were left unchanged while the base board was transformed yet again. It mimics Sketch Model 8 in that the base board's shoulder area has been reduced but in this model the design of the base board slowly returns to its full diameter. This tapered design was meant to provide extra head centering strength that the previous model lacked. In addition, two holes were cut from the base board's front semi-circle to help balance the buoyancy of the device.

Although the design of this Sketch Model 9 was constructed with the goal of a possible design solution, its functionality did not perform as well as expected. This model did exceed the previous model's ability to stabilize the head, but in doing so the buoyancy at the front of the device was still too great. A possible solution to this concern would be to remove more material from the front of the base board and add material to the back. A tenth sketch model design was drawn up but due to time and material constraints only a SolidWorks model was created. (Section 2.2, Figure 20)

On a brighter note, the neck and head support that have been used in combination with the fins on the base board have received positive reviews. These supports provide adequate stability and lift for people ranging in weight from 60 pounds up to 250 pounds that were tested. These critiques will assist in future stages of the design process because

the only element with uncertainty is the outer portions of the base board. When the new materials arrive, Sketch Model 10 and any future necessary revisions can be created in minutes rather than days by utilizing SolidWorks.

2.1b Connectors

When the sketch model process began, no longevity was intended from each prototype. The entire inspiration behind the preliminary designs was to get as many working models as possible for the purpose of evaluation. As each model was constructed, ease of assembly of the model was a priority. As each model was assembled and tested, many enhancements were visualized and listed as possible revisions to the appropriate model. Once a distinct improvement was identified, new components would be cut from the old kickboards and assembled for another round of testing. For Sketch Models 1 through 6, each part was hand made and then either glued or nailed to the other components of the model. This crude approach during the early development phase was acceptable but it was obvious that this method had to be revised for final production.

The decision regarding the appropriate material to order for this apparatus involved much consideration. Several factors evolved but conquering the production issue was essential in this decision. The final product had to be easily assembled with out the use of outside materials such as glue or nails. Foam was the material of choice for *The Back Stroke Buddy* and this was a definite production advantage because foam can be easily made to snap together. (Appendix D: Section 2) Many snap-fit designs were considered and tested before adding them onto the actual components. The snap-fit design consists of two parts: one piece with a protrusion and another with a cut-out. (Figure 13, A and B respectively) The piece with the hole in it was quite simple to create, while the piece with the protruding end was much more involved.

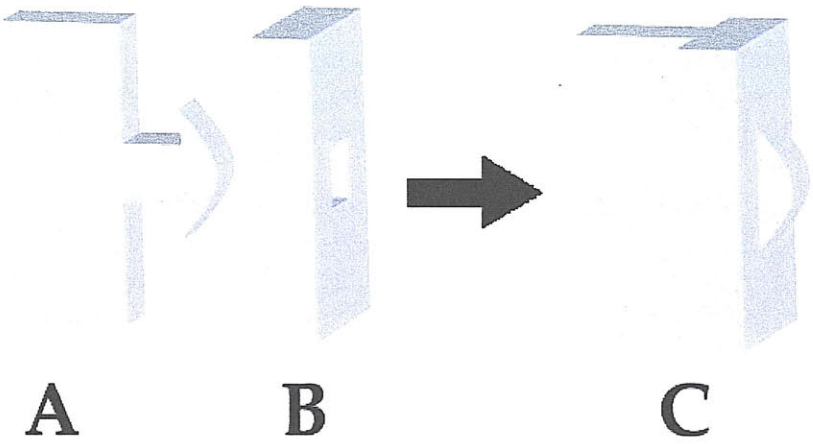


Figure 13: Snap-fit design used in final product.
A slides through B creating the connection C.

The component with the protrusion had many possibilities before it became the part pictured in Figure 13 A. To decide on possible designs for this protrusion two main

considerations were explored. First and foremost the connection had to be secure, meaning that unless excess force was applied nothing would separate the two pieces. The secondary factor was simply aesthetics. In order to gain insight and design prototypes as to how pieces snap together, a set of sample protruding ends were created. (Figure 14)

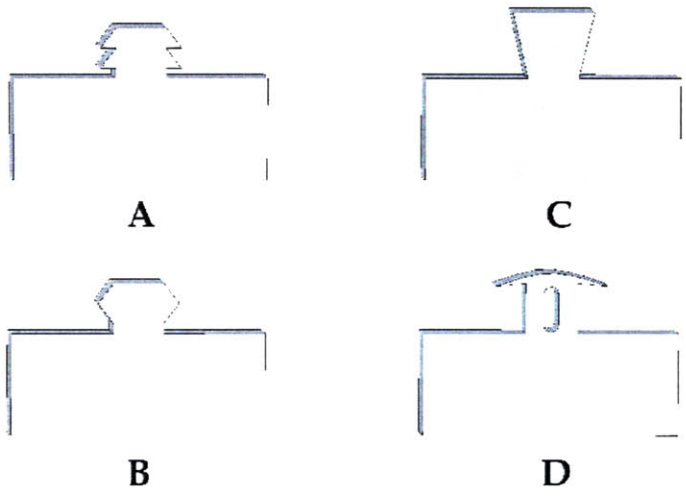


Figure 14: Four sample protrusions
created for testing snap-fit represented in Figure 15.

The pieces in Figure 14 A and B lie flush when pushed into a hole while the pieces in Figure 14 C and D are meant to go through the hole and come out on the other side. From the aesthetics point of view, the parts in Figure 14 A and B would lend the better appearance because nothing protrudes on the other side, but since this is a secondary factor to the needed strength, this aesthetic observation was ignored. When testing these four pieces, each one created a tight fit but the two aesthetically dominant pieces could not handle the forces of usage. The piece in Figure 14 C would also dislodge under a large but possible load leaving Figure 14 D as the optimal part. This snap-fit design could handle the stresses required but its side flaps, represent as length L on Figure 15, degraded significantly by the end of testing. Since there was an optimal design in terms of strength from the four tested, a revised version of Figure 14 D was created. (Figure 15)

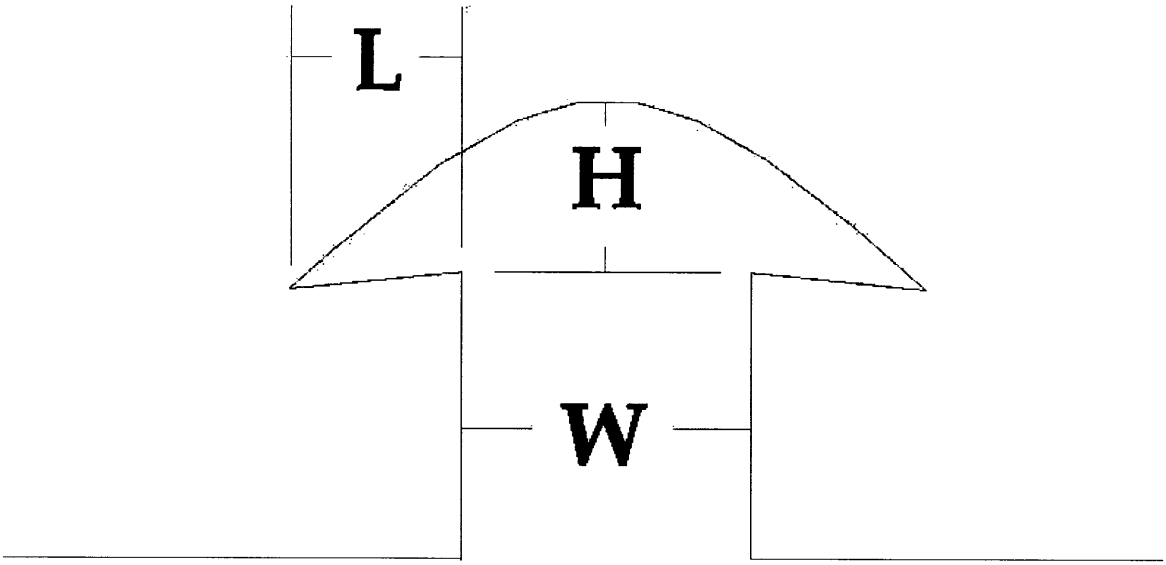


Figure 15: Final snap-fit design for the protruding piece.

The key advantage of this design over the previous is the increased flap height. This difference enabled the side flaps to keep their rigidity and not degrade or bend back after usage. After reviewing the results from the testing, no further work was needed on the general design shape. Yet, since there were multiple connections in this device, this required investigation because each structural interface between two components varied in size. During the testing of these interlocking pieces, it was observed that the center hole pictured in Figure 14 D, designed to ease the assembly process, did not significantly affect the time required or ease of assembly so it was removed. This was small scale assembly and was accomplished by making multiple versions of the piece in Figure 15 and testing their viability while noting some limitations. The width of the piece, W, for 1 inch thick foam should not be less than about ¾ inch because as the components were snapped together, as in Figure 13, the protrusion part may get damaged. The flap height, H, should at least equal the flap length, L, to ensure a durable, secure fit. Lastly, the side flaps are angled slightly to ensure the connection stays snug at all times; any angle greater than 5 degrees accomplished this.

2.2 Final Design

The design I will present is the Sketch Model with the best performance, not necessarily the most recent model. The reason for presenting an earlier model is that it outperformed every other model in design and functionality. Sketch Model 7 has demonstrated the most promise and has the best test results. This model can support the head and neck, provide protection from any obstacles found in pools, stabilizes the swimmer's head in the center, and never deviates from the intended route. This version of *The Back Stroke Buddy* performed above expectations and fulfilled the requirements from the original proposal. The only function that has not been resolved is discussed in detail in Section 2.1a. The

limitation pertains to the full range of arm motions while using this apparatus. Sketch Model 7 will be the prototype presented to the public as well as potential companies of interest.

Although there are design modifications of the base board in progress, this model exemplifies the core principles of *The Back Stroke Buddy* and is in itself viable as a product. To understand how this device is actually assembled, each component has a few attributes which were not described during the sketch model stage and will now be addressed. The following describes the major features of each component but for the exact dimensions, see Appendix B.

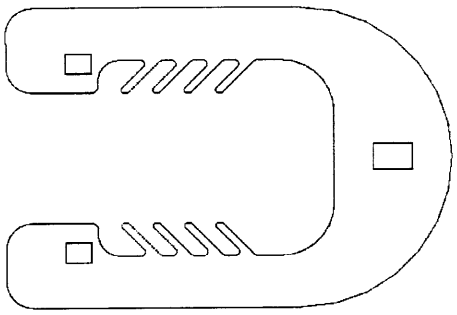


Figure 16: Base board for the final design.

This base board is almost identical to the base board in the first sketch model. The dimensions have not changed and the only additions were four stabilizer fins on each side of the board. The head and neck support cradle the head while the base board must stabilize the entire device and maintain the centering of the head. This base board may not be optimal in terms of material usage because it was made in a disproportionate size in order to be a building block for future designs. Despite this fact, so far no other design has rivaled its success. The unique feature that separates this model's success over all the preliminary sketch models is its fins. These fins eliminated the need for two materials and perform as well as the elastic bands.

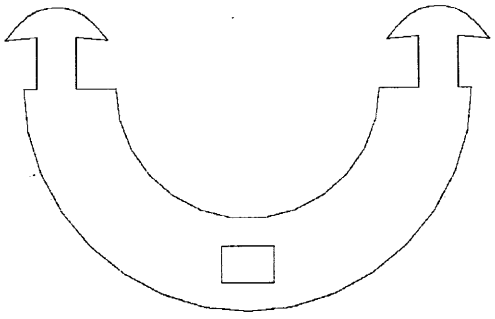


Figure 17: Neck support for the final design.

Even more so than the base board, the neck support did not change significantly after Sketch Model 2. Once it was recognized that the optimal head position was having the ears in line with the base board and the neck support lower, there were no further changes incorporated in this area. The radius of the neck support was varied week to week by less

than a ¼ inch to determine if there was any noticeable difference. This change in the neck support width did vary the comfort levels of the swimmers but when the material was switched to softer, more pliable foam, no one mentioned this concern when utilizing this product in the water.

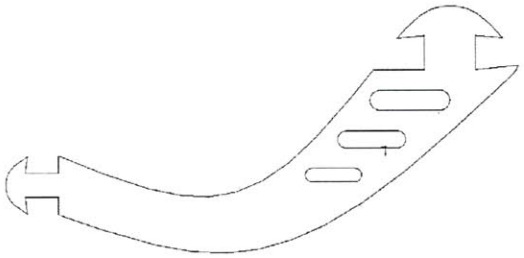


Figure 18: Head support for the final design.

This head support began as elastic bands and was metamorphosized into the foam piece seen in Figure 18. This transformation was mainly due to the desire to have protection for the head but later evolved from a nuisance into an essential safety component of the device. The design of this piece has the same structure as the first head support foam model except its design allows decreased buoyancy while maintaining its strength. Two other features added to this design were having the front of the head support (farthest right point in Figure 18) angled slightly up, mimicking the snap-fit design angling and having the front slightly rounded. The purpose of these modifications was to allow the head support to pinch the front of the base board so that no matter what *The Back Stroke Buddy* struck, the tip of the head support would never bend or rip.

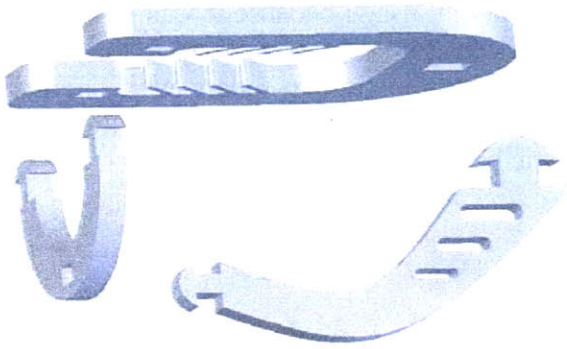


Figure 19: The three components of the final design
prior to snap-fitting them together.

These three components, the base board, head support and neck support, all merge to form the final version of *The Back Stroke Buddy*. The components are snapped together forming a semi-permanent structure seen in Figure 10. Semi-permanent means that once this device is assembled, it should remain assembled. If the user attempts to take this device apart it may develop a tear in the foam causing a snap-fit to rip off. This is not a major concern because this product is not large or difficult to store so disassembly is not required. Also, for storage it can be hung on a hook or thrown in a bin with the rest of the pool toys without facing damages.

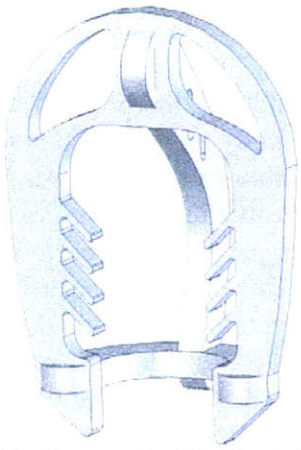


Figure 20: What's next for *The Back Stroke Buddy*.
Sketch Model 10- to be tested soon.

This final design does exist for *The Back Stroke Buddy*, in addition to other modified designs, but none of these later prototypes have been put through testing at this time. The design picture in Figure 20 follows some of the modifications suggested from Sketch Models 8 and 9 but also encompasses additional revisions. The projection is for this to successfully accomplish all the desired revisions surpassing all the expectations set forth and become the new *Back Stroke Buddy*. The head and neck supports are unchanged from the present final design and there are no revisions planned for the inside of the base board. In this model, the only change is that material from the front, sides and back of the base board will be removed. The plan is that by modifying both the front and the back of the base board, a suitable equilibrium will be created. The proposal to leave material near the shoulders may still inhibit some movement but when compared to the present final design, the increase in arm mobility will be substantial.

3.0 Future

A final prototype for *The Back Stroke Buddy* now exists but what is the next step? Should this proposal be submitted for thesis credit and forgotten? This is a feasible option but after developing this inspirational idea from concept to sketch models, utilizing discarded kickboards, super glue, duck tape, Bungi cords, old backpacks, paper clips, rope, pennies and sponges to finally adopting a snap-fit foam design and seeing its effectiveness, this device cannot be shelved. The fact of the matter is that *The Back Stoke Buddy* works as a teaching tool, as protection against obstacles in the water, including pool walls, and it fits a wide range of head sizes comfortably. Almost every challenge that surfaced with each progressive sketch model was addressed and solved serving to refine this device's form and functionality, and the final remaining challenge solution is in the making.

Due to *The Back Stroke Buddy's* success thus far, a patent application is being filed and possible production sites are being explored. The future is unclear but its potential as a viable product is well worth exploring.

3.1 Market

As a potential innovation, the demand for this product will initially be limited to those with access to a pool or an open body of water. This does decrease the number of potential buyers but pool products are known to have a successful market of their own. The next step is to identify every possible use of *The Back Stroke Buddy* and determine a client base. The main service of this product will be to provide comfort and security to beginner and novice swimmers as they become accustomed to floating in the supine position in the water. As long as a person is old enough and proficient enough to enter a body of water on their own, s/he can use this device. Whether it is used in a swim lesson with multiple students or by a swimmer practicing on their own, this product will perform as intended. It is not only a teaching device but also one that can be utilized by any proficient swimmer who wants to strengthen their backstroke kick or even those experienced individuals interested in protecting their heads from bumping into the pool walls.

Some potential buyers may include:

- facilities which offer swim lessons to new swimmers,
- facilities looking to offer a wide range of pool equipment for patrons, (Figure 21)
- parents teaching their children how to swim,
- adults uncomfortable on their back in the water,
- adults who bump their heads on pool walls while swimming on their back,
- swimmers and cross-training athletes kicking laps on their back,
- and many more.

The assistance this product can provide varies from person to person but due to its multi-functional capabilities, the applications of the device are not limited to simply being a teaching aid.

Figure 21: *The Back Stroke Buddy*
among other commonly used pool training devices.

3.2 Production

Due to *The Back Stroke Buddy's* potential as a marketable idea and its wide audience of promising buyers, a methodology for large scale production needs to be explored. For an item such as this, enticing an already established company as a production partner is the easiest route to success. Although this is a novel idea, developing it into a production ready format will attract companies even more. As the final design stands to date, it consists of three components, each of which can be water jetted from a large sheet of foam. Constructing the entire product out of one material and selling the product unassembled will drastically cut down on materials, labor costs, and shipping expenses.

3.2a Final Product Package

As the product comes off the production floor, there will essentially be bins full of base boards, neck supports and head supports. The next and final step before shipping these components to stores is deciding how to package them in a concise yet attractive manner. Since each piece of the apparatus is flat and the same thickness, the most logical way to package the three components is to have them lie next to each other. (Figure 22) This will not only protect the integrity of each component but also ease shipping of large orders as each bagged product can be stacked flush against the next.

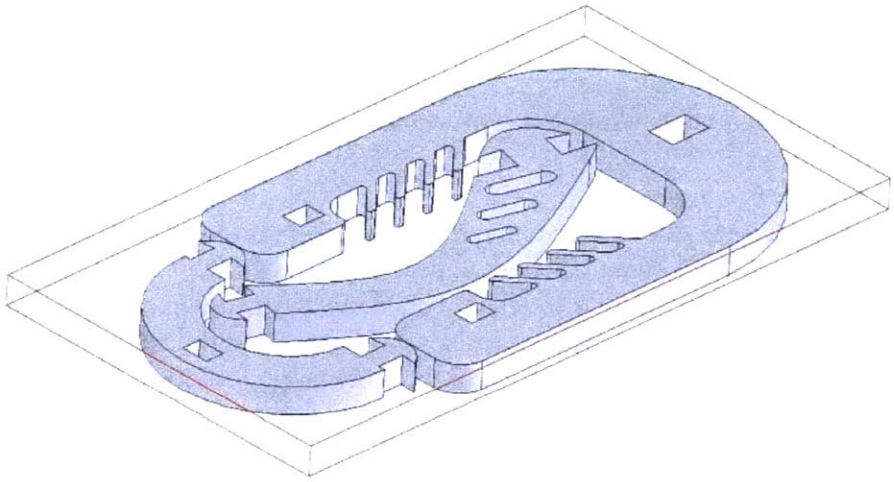


Figure 22: Unassembled version of *The Back Stroke Buddy* ready to be packaged and shipped.

APPENDIX A

Thesis Proposal
February 28, 2005

For my final project here at MIT, I want to do a project that I can not only be proud of, but one that also means something to me on a more personal level. I plan to utilize the skills I have developed at MIT as a Mechanical Engineering student and combine them with my passion for athletics. The training methods for many sports have already been studied and refined and therefore I would like to focus on cross training and rehabilitation. Coming from a diverse sports background, I know the difficulties involved with maintaining athletic prowess in multiple sports. However, in doing so, I have also witnessed the numerous benefits: overall strength increase, stronger cardio/respiratory systems, and muscle development, to name a few.

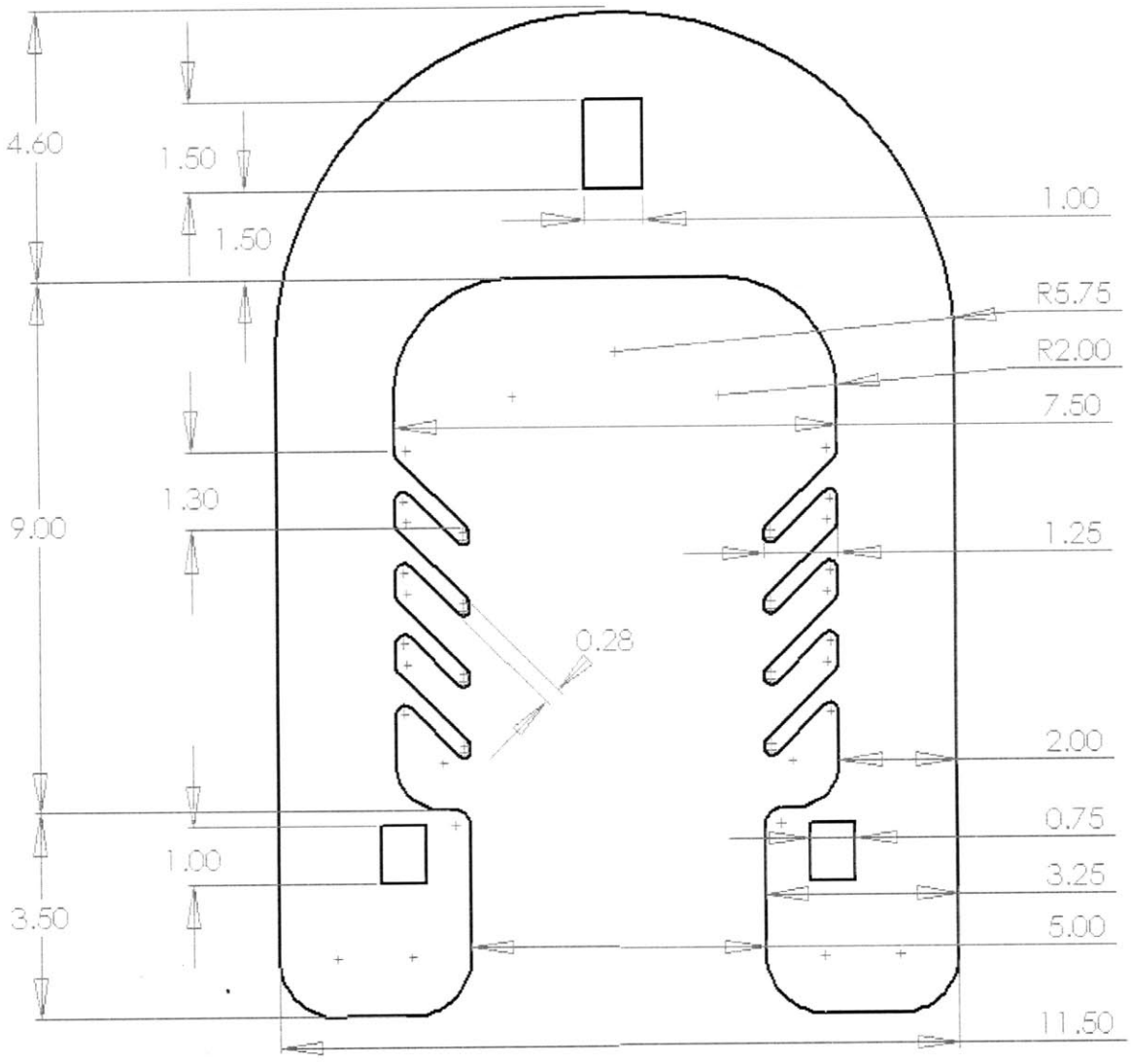
In order to accomplish this task, I plan to develop a piece of cross training equipment which can benefit an athlete who participates in a wide variety of sports. The preliminary stages of this research pointed to an aqua-cross training piece of equipment. When trying to develop this concept as well as a target audience, I was able to come up with an idea that not only fits my preliminary ideas but also expands its impact. My thesis project's new goal is to help teach people how to swim. This will affect athletes by teaching many a new swimming stroke with which to train but now, this also will affect a much wider audience by becoming a teaching tool for anyone involved in swim lessons. My thesis project will involve a kickboard-like device that will enable floating on one's back. This evolved kickboard will lie under one's neck when first learning to float on their back. The purpose of this is to get a new swimmer comfortable on their back so s/he can focus on learning backstroke.

The original inspiration for this device came from teaching children how to swim. When first learning to float on their back, constant supervision and support are needed by the instructor which limits his/her ability to teach a class. With this device, the instructor could have a whole class practice these exercises at once saving time and money. Once the prototype is completed, I plan to test the product by using it in my and other instructors' lessons. Hopefully this product will increase the quality of the swim classes and make swimming on your back possible for all.

APPENDIX B

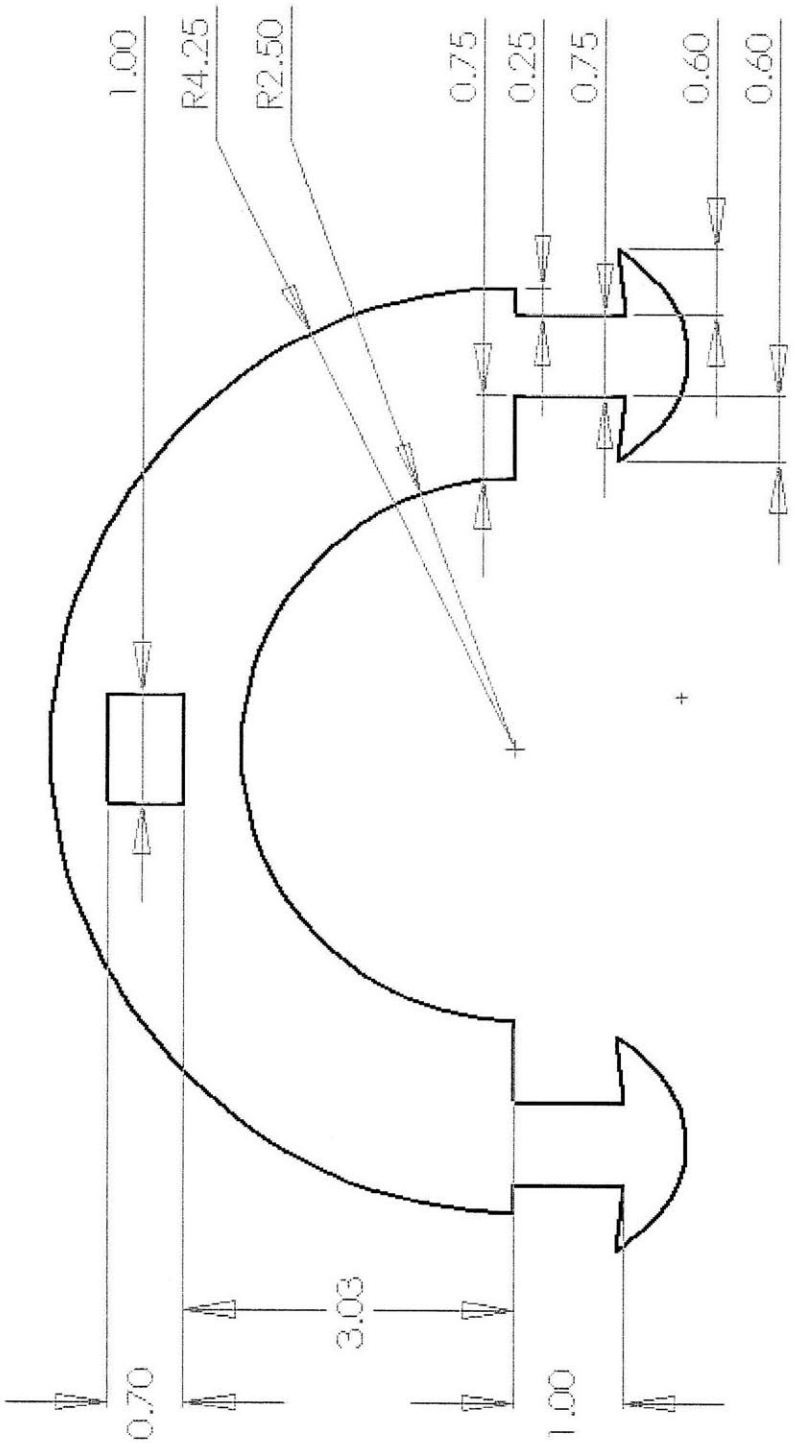
Final Design Dimensions (in inches)
Each piece is cut from foam with a thickness of 1 inch.

Base Board



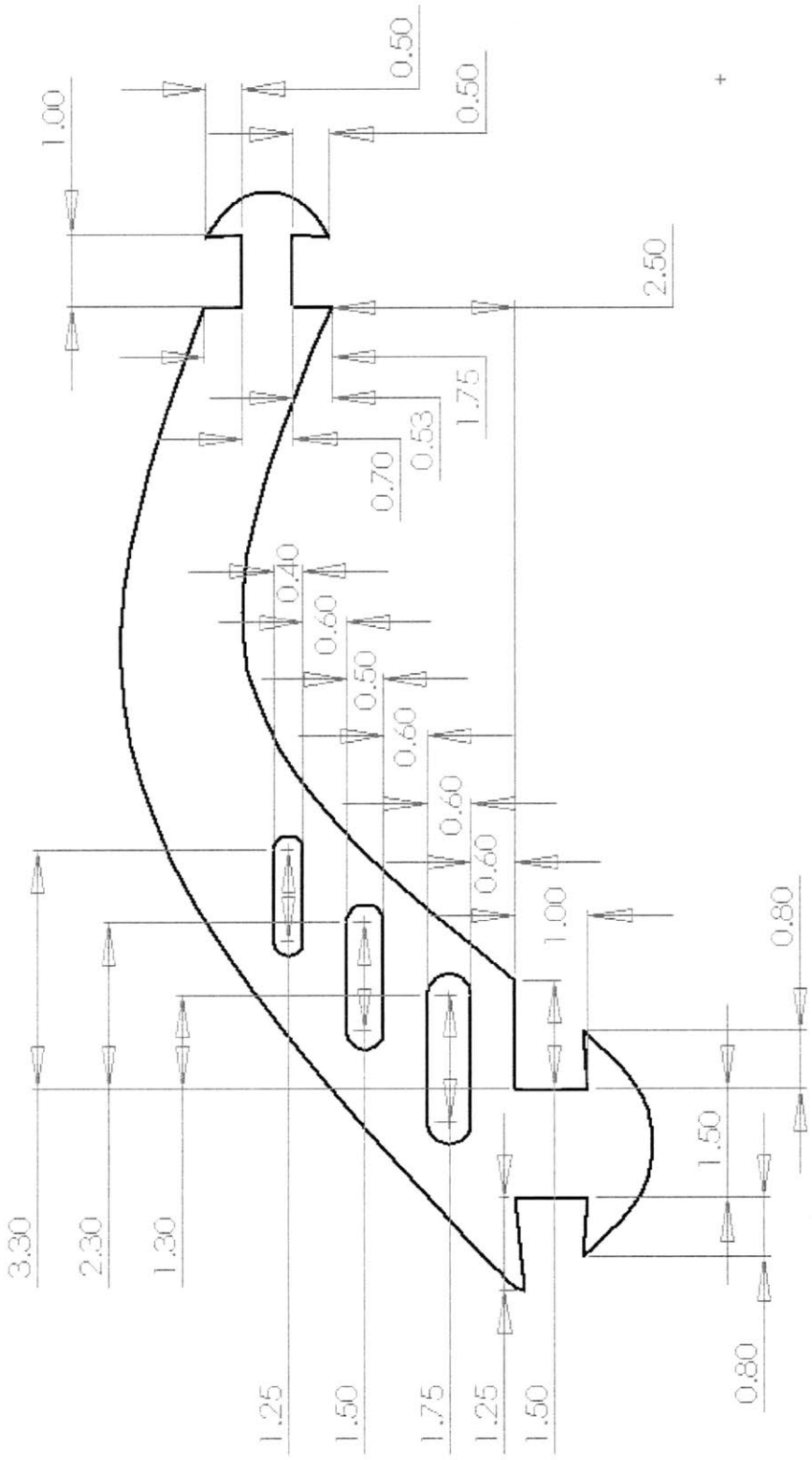
Final Design Dimensions

Neck Support



Final Design Dimensions

Head Support



APPENDIX C

Important Dates

Jan 31 Chose to enroll in PE for ME (SP.250/2THU).

Feb 1 First class, decided thesis must involve some aspect of physical intelligence.

Feb 8 Possible theses include cross training equipment either in water or on land.

Feb 14 Sketched three cross training devices, one of which was a version of *The Back Stroke Buddy*.

Feb 15 Presented all three drawings to the class and received feedback on each of their feasibilities and uniqueness.

Feb 20 Selected *The Back Stroke Buddy* drawing and started sketching up blue prints for the first sketch model. Also requested donations from the MIT Z-Center pool.

Feb 21 Cut out and assembled Sketch Model 1 from old MIT kickboards.

Feb 22 Presented Sketch Model 1 to the class and used the model in the pool.

Feb 28 Wrote thesis proposal for this pool training piece of equipment.

Mar 1 Presented Sketch Model 2 to the class.

Mar 8 Presented Sketch Model 3 to the class.

Mar 15 Presented Sketch Model 4 to the class.

Mar 29 Presented Sketch Model 5 to the class.

Apr 5 Presented Sketch Model 6 to the class.

Apr 7 Met with Professor Slocum to discuss progress of device and design plans for water jetting. Ordered 10 new kickboards made from softer foam than the original MIT Z-Center kickboards.

Apr 12 Presented SolidWorks plan for water jetting Sketch Model 7.

Apr 17 Completed MIT Technology Licensing Office technology disclosure application.

Apr 19 Sent out TLO technology disclosure application.

Apr 20 Designed second SolidWorks plan for water jetting Sketch Model 8.

Apr 26 Presented Sketch Models 7 and 8 to the class.

Apr 27 Filled and sent out TLO waiver form.

Apr 29 Presented Sketch Model 9 to Professor Slocum and designed Sketch Model 10.

May 2 Mailed temporary thesis to patent office for approval.

May 3 Theses fair for PE for ME in Z-Center front lobby showcasing each thesis.

May 6 Handed in final draft of the thesis.

APPENDIX D

Outside Contributors

SECTION 1: Supplies

MIT Zesiger Sports and Fitness Center- Aquatic Department

- 10 used kickboards

Professor Alexander H. Slocum- MacVicar funds

- 10 new kickboards

SECTION 2: Design Aspects

Professor Alexander H. Slocum

- fins on underside of base board for steering purposes
- rigid head support
- fins on the inside of the base board to keep the swimmer's head centered
- snap-fit connectors

APPENDIX E

Technology Licensing Office Application

Cover Letter

To: Carl Berke
From: Alex Slocum
Subject: Greg Fonder's SB thesis and invention disclosure
Date: 4/19/2005

Dear Carl:

Attached is an invention disclosure form for a pool-toy made from foam that a student, Greg Fonder, has done for his SB thesis in Mechanical Engineering. I helped in the design and provided about $50 from my MacVicar funds for foam. He cut the parts with hand tools and we tested them in the MIT pool.

Since this does not constitute significant use of MIT resources, I would like to propose that MIT says the idea is for the inventors to do with as they wish. We will file a provisional patent and then try to sell it, but as you know, the toy market is very tough to say the least.

May 8 we are showing the idea in the Z-center, so if you could let us know by April 26.

Sincerely,

Alex Slocum

Technology Licensing Office Application

Application

When completed submit via:
Technology Licensing Office
Room NE25-230
617-253-6966

Massachusetts Institute of Technology
TECHNOLOGY DISCLOSURE

Case No. (this space for TLO use only)

Instructions on reverse

ITLE OF INVENTION: Back Stroke Buddy

2. PLEASE ATTACH DESCRIPTION OF TECHNOLOGY

3. INVENTOR(S)	POSITION	DEPARTMENT	M.I.T. ROOM NO. & EXTN.
Gregory P. Fonder	Student	Mechanical Engineering	
Alexander H. Slocum	Professor/Advisor	Mechanical Engineering	3-445 & 3-0012

4. Was this invention developed with the use of any research grant/contract funds? YES ☐ NO ☒

CONTRACT NO(S).	SPONSOR(S)	O.S.P. PROJECT NO(S).	PRINCIPAL INVESTIGATOR
none			

Please note that accurate and complete sponsorship information is necessary to fulfill M.I.T. obligations under research contracts.

5. If no contract or grant, was there significant use of M.I.T. administered funds or facilities as defined in Instructions? YES ☐ NO ☒

6. DATES OF CONCEPTION and PUBLIC DISCLOSURE (accurate data is essential as prior disclosure may affect the possibility of obtaining patent rights)	DATE	REFERENCES/COMMENTS Please include names of periodicals/journals. (use separate sheet if necessary)
A. Date of conception of invention. Has this date been documented? If so, where?	2/22/05	Lab Notebook
B. First publication containing sufficient description to enable a person skilled in this field to understand and to make or use the invention. (include theses, and the date submitted)		
C. First public oral disclosure of invention sufficient to enable a person skilled in this field to understand and to make or use the invention.		
D. If unpublished and undisclosed, provide the anticipated publication or oral disclosure date and any submissions made for initial publication.	5/10/05	

7. Has the invention been reduced to practice? YES ☒ NO ☐ If yes, please give date of first reduction to practice 3/01/05.

8. Please attach list of any commercial entities that may be interested in this invention. (provide as much detail as possible)

9. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true.

I (We) hereby agree to assign all right, title and interest to this invention to M.I.T. and agree to execute all documents as requested, assigning to M.I.T. our rights in any patent application filed on this invention, and to cooperate with the M.I.T. Technology Licensing Office in the protection of this invention. M.I.T. will share any royalty income derived from the invention with the inventor(s) according to its standard policies.

Inventor's Signature 4/17/05 Date	Inventor's Signature Date
246 Manchester Rd., River Edge, NJ 07661 Home Address	Home Address
Social Security No. (required) USA Country of Citizenship	Social Security No. (required) Country of Citizenship
Inventor's Signature 4/19/05 Date	Inventor's Signature Date
1 Merrill Crossing Bow NH 03304 Home Address	Home Address
on-file USA Social Security No. (required) Country of Citizenship	Social Security No. (required) Country of Citizenship

Please note that Social Security number and country of citizenship are required; absence of this information may hinder distribution of the inventors' share of any royalties that may result from this technology. If there are more than four inventors, please attach additional form.

Technology disclosed to and understood by:

Signature of Non-Inventor Witness_____ Date_____

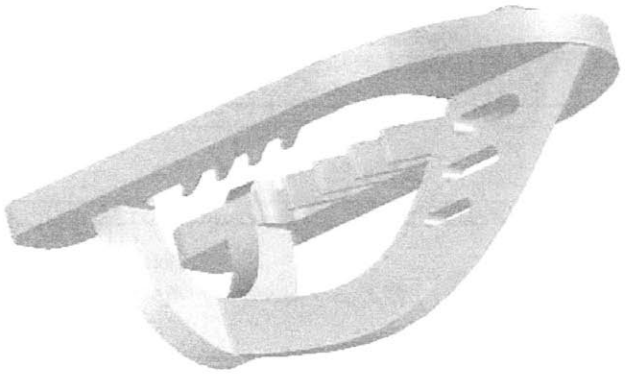
Name and Title of Witness (please type or print)_____

(1/15/2002)

Technology Licensing Office Application

Description of Technology

The Back Stroke Buddy



As inferred from its name, the goal of this device is to assist people when swimming on their backs. While learning to float or swim on one's back, many issues arise which can make a person uncomfortable and scared to be on their back in the water. These problems include water splashing onto one's face interfering with breathing and one's head bumping into objects such as the pool wall or other swimmers. To help these people to learn to swim on there back, *The Back Stroke Buddy* will eliminate these nuisances. To accomplish this task, *The Back Stroke Buddy* will:

- keep the intended swimmer's head high enough out of the water to minimize splashing onto one's face,
- provide protection to the swimmer's head from obstacles such as lane lines, walls and other swimmers,
- keep the swimmer's head looking straight up to help teach the swimmer proper backstroke technique.

Not only will *The Back Stroke Buddy* perform these services but it will not interfere with one's stroke. This will enable any person to safely practice swimming on their back whether s/he is first learning how to swim or is an experienced swimmer.

The Back Stroke Buddy is a kickboard-like apparatus that will enable floating on one's back by supporting one's head and neck. This evolved kickboard will lie under one's neck, have a foam support running along the back of one's head, and also surrounding the sides of the head. Each of the three pieces has many considerations ranging from comfort and support to protection. The primary purpose of the neck piece is to simply keep one's chin well above the water. The head support has two purposes; to protect the head from walls and allow the head to rest over the center of buoyancy. To make this happen, this piece has some holes in it strategically placed to decrease the piece's buoyancy but not affect its strength. The final piece is the body of *The Back Stroke Buddy*. This piece is responsible for stabilizing the entire apparatus, keeping the head centered (2 sets of four prongs as seen in the picture), and protecting one's head from any floating obstacles in the water. To connect these three pieces, snap fits will be used enable *The Back Stroke Buddy* to rise from 2-D to 3-D.

While there are many pool toys and floatation devices, none can accomplish what *The Back Stroke Buddy* can. The two most widely used teaching devices are the kickboard and noodle. While the kickboard has been used for many years and is the generic teaching device, its simplicity limits its functionality. While it does enable a swimmer to practice his/her kicking, both of his/her arms must be used to hold the kickboard. The noodle on the other hand does allow a person to practice swimming with their arms and legs because it can bend around one's body but again, this added flexibility also limits its functionality. While it is very popular with new swimmers, once someone is past the preliminary stages of learning to swim, the noodle becomes obsolete due to its large size. *The Back Stroke Buddy* allows swimmers to practice with there arms and legs while not hindering more experienced swimmers. The main aspect that brings *The Back Stroke Buddy* into a category all by itself is its neck piece. This support, combined with the rest of the apparatus, lifts and supports the head while not interfering with swimming. And unlike pool products like the aqua-jogger, a swimmer has all the benefits of this device while not being strapped in to it. In addition, the added protection that *The Back Stroke Buddy* provides makes this device revolutionary compared to what exists.

The Back Stroke Buddy, due to its unique features and the fact that one size fits all, can become an added amenity to any pool establishment or teaching facility. This device can be used as a teaching tool or simply another piece of pool equipment of which pool patrons could take advantage. *The Back Stroke Buddy's* 2-D design allows ease in cutting it out of any foam material and it can be shipped flat and assembled on location. This will decrease the price of *The Back Stroke Buddy* so that anyone could have one if they wanted it. The limitations are that one can only practice swimming on his/her back using this device. While *The Back Stroke Buddy* appears to be more of a specialty item that pools can offer, its low production cost and advantages over what exist will make *The Back Stroke Buddy* a must have for any pool.