



How to Make More Shots

Basketball shooting percentages have been flat or decreasing at all levels of competition. For example, the National Basketball Association average free throw shooting percentage has been constant at about 74% since 1958. It is difficult to think of a performance statistic in any other sport that has shown no improvement in the last 45 years.

At Noah Basketball, we have spent a number of years investigating the arc of outside shots and how arc affects shooting percentage. Our research included numerous studies of ball flight, two scientifically controlled motor skill studies and thousands of Noah feedback sessions with basketball players from middle school through NBA professionals. We observed that most shots miss because they are too short or too long. Distance of a shot is controlled by arc and shooters at all levels have great difficulty controlling the arc of their shots.

This short paper summarizes the Noah Basketball learning. We begin the paper by explaining the important concepts of arc. Then we give some examples that show how much scoring percentage increases with improved arc control.

What is Arc?

Arc is the path the basketball flies from the time it leaves the shooter's hand until it arrives at the basket. Once in the air, gravity is the only force affecting the ball, so the flight is completely predictable for a given release direction, release point and release strength. Photo 1 shows the ball flight at multiple times on the way to the basket. The ball flight always takes the shape of a parabola.





Photo 1
Basketball Arc

By drawing a line through the center of the ball in Photo 1, we can visualize the exact parabolic path that the ball takes from the shooter's hand to the basket. This visualization is shown in Photo 2.

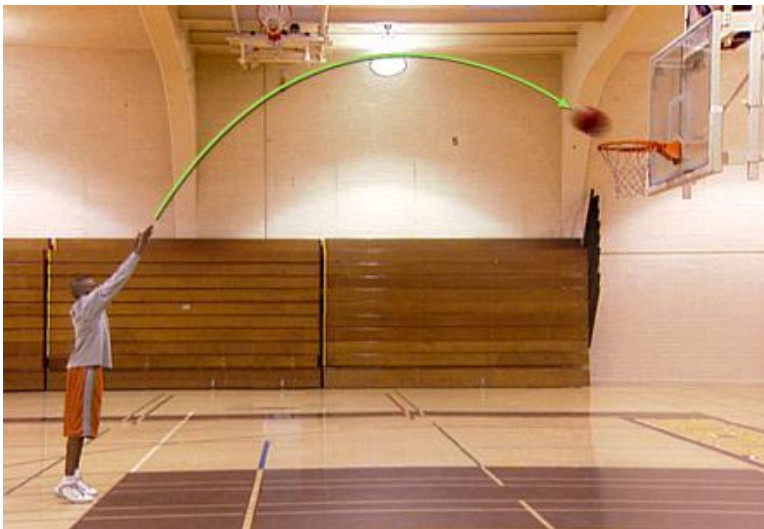


Photo 2
Arc Visualization

Measuring Arc

Some diagrams will help to clarify the important concepts. We define arc as the angle that the ball enters the hoop, because what matters in scoring is what happens at the hoop. If a ball enters the hoop directly from above, this is a 90 degree arc. Unless you are dunking the ball, a 90 degree arc is impossible. Free throws and jump shots always come into the hoop at an angle. A ball entering the hoop directly from the side is a 0 degree arc, which is impossible to score. Figure 1 shows shots with a variety of arcs. The red line represents a 30 degree arc, which is very low. The blue line represents a 65 degree arc, which is very high. Finally, the green line represents a 48 degree arc, a more appropriate height.

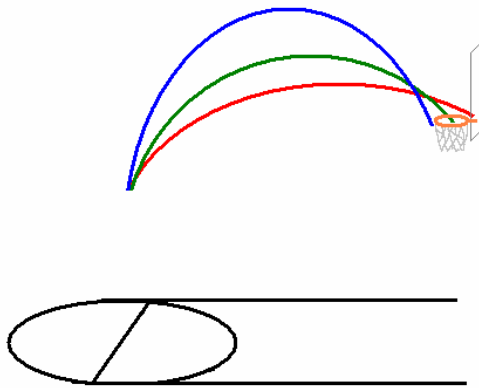
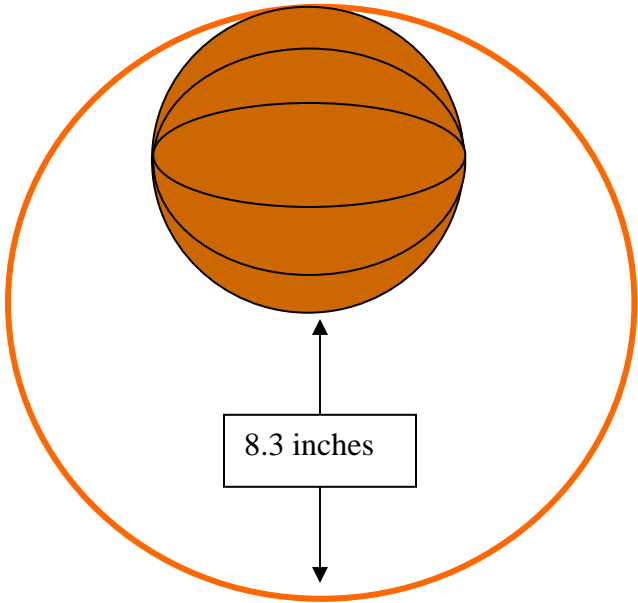


Figure 1
Range of Arcs
Red = 30 degree arc
Green = 48 degree arc
Blue = 65 degree arc

Apparent Hoop Margin

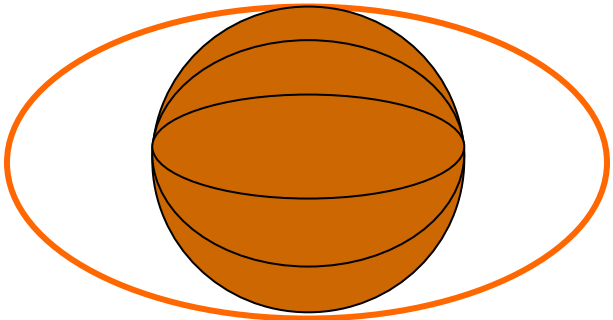
If a ball enters the hoop directly from above, this is a 90 degree arc. If the 90 degree ball had eyes, the hoop would look perfectly round with an 18 inch opening as shown in Figure 2. Since a men's ball is 9.7 inches in diameter, the amount of open space left in the hoop is $18 - 9.7 = 8.3$ inches. This is called the hoop margin.

Figure 2
 90 Degree Arc
 Hoop Size = 18.0 inches
 Hoop Margin = 8.3 inches



Jump shots and set shots from the outside do not enter the hoop with a 90 degree arc. Instead they enter at an angle which means that the hoop looks like an ellipse rather than a circle. The flatter the arc, the smaller the ellipse, called the *Apparent Hoop Size*. If a 32 degree ball had eyes, the hoop would look just large enough for the ball to squeeze through as shown in Figure 3. The *Apparent Hoop Size* is 9.7 inches, the same size as a men's basketball. Now we can calculate the *Apparent Hoop Margin*, which is the *Apparent Hoop Size* minus the diameter of the ball. At an arc of 32, the *Apparent Hoop Margin* is 0 inches, allowing no room for shooter error.

Figure 3
 32 Degree Arc
 Apparent Hoop Size = 9.7 inches
 Apparent Hoop Margin = 0.0 inches



As the arc is increased to 35, 45 and 55 degrees, the *Apparent Hoop Size* and the *Apparent Hoop Margin* become larger as shown in Figures 4, 5 and 6.

Figure 4
 35 Degree Arc
 Apparent Hoop Size = 10.3 inches
 Apparent Hoop Margin = 0.6 inches

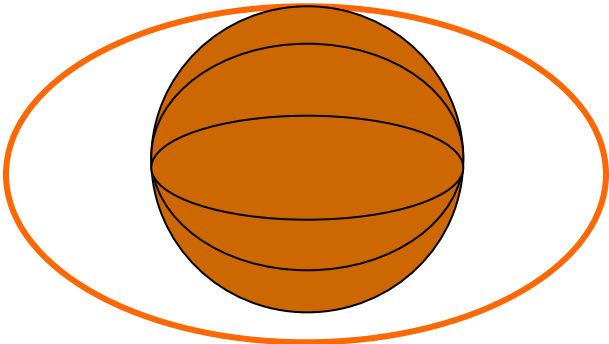


Figure 5
45 Degree Arc
Apparent Hoop Size = 12.7 inches
Apparent Hoop Margin = 3.0 inches

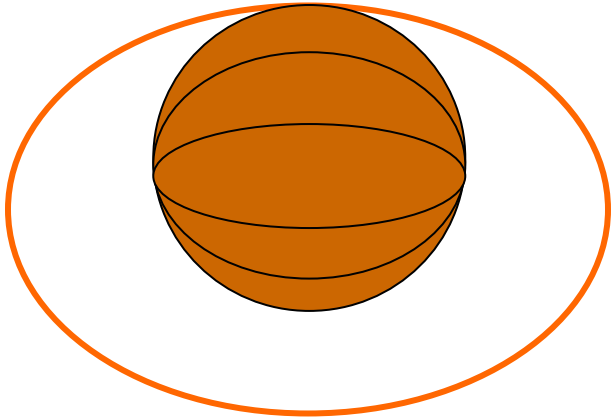
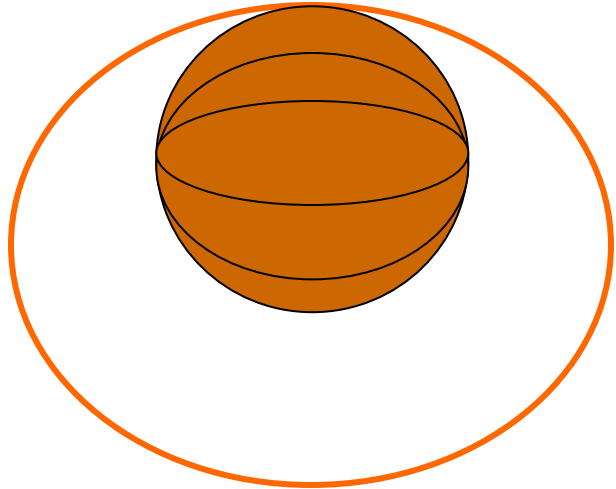
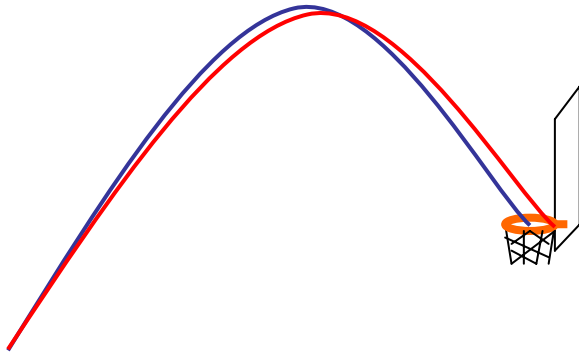


Figure 6
55 Degree Arc
Apparent Hoop Size = 14.7 inches
Apparent Hoop Margin = 5.0 inches



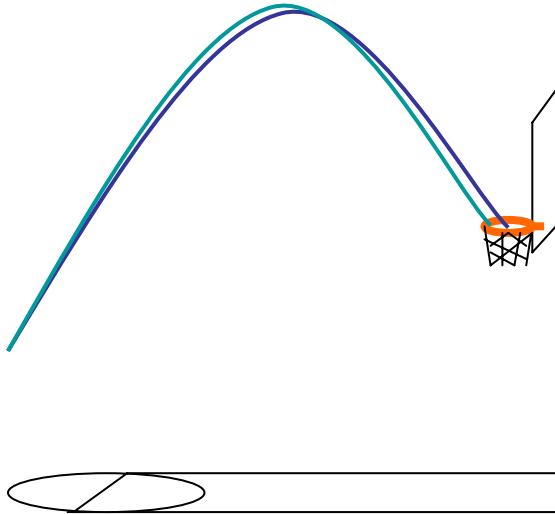
If the Apparent Hoop Margin is larger for a higher arc, then it seems like the higher arc would lead to more made shots. Unfortunately, Apparent Hoop Margin is only part of the scoring story. The other key issue is distance control. Even with the same level of shooting skill, physics laws show it is more difficult for a shooter to control distance when shooting a higher arc. This explains why the best shooters do not have extremely high arcs on their shots. Some diagrams will help to explain. For example, even though the hoop gets larger as the arc increases from 45 to 55 degrees, the loss of distance control increases even more than the increase in Apparent Hoop Margin. Figure 7 shows a shooter with a 6 foot release height trying to shoot a 3-point shot with a 55 degree arc (shown in blue). The 55 degree arc goes through the hoop. But if the shooter accidentally shoots 1 degree lower, a 54 degree arc (shown in red), the laws of physics will cause the ball to travel a greater distance. In fact the ball will go exactly 3.3 inches further; just enough to bounce off the back of the rim.

Figure 7
 3-point shot with 6 foot release height
 Blue arc is 55 degrees
 Red arc is accidentally 1 degree lower



If the shooter accidentally shoots 1 degree higher, a 56 degree arc (shown in green) in Figure 8, the ball will travel 3.6 inches less and bounce off the front of the rim.

Figure 8
 3-point shot with 6 foot release height
 Blue arc is 55 degrees
 Green arc is accidentally 1 degree higher



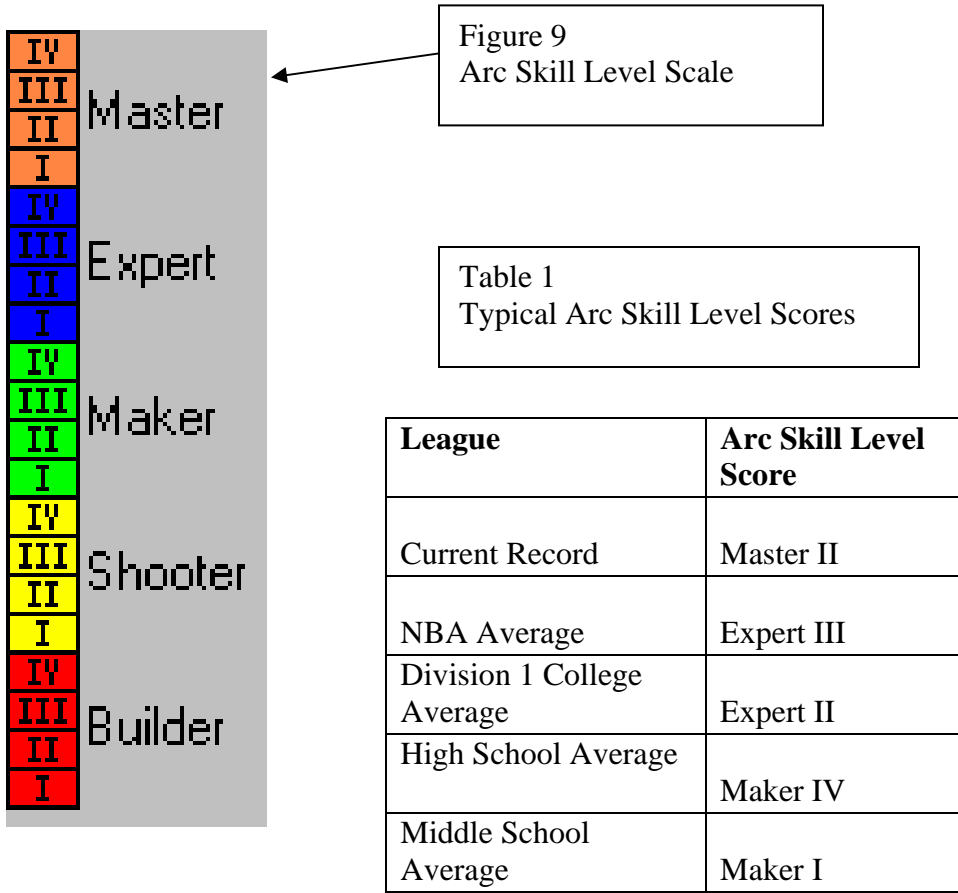
From the figures above, we learn that there are a range of arcs that are optimal. Arcs that are too flat have too little Apparent Hoop Margin. Arcs that are too high have too little distance control. Optimal arcs are more forgiving, allowing the shooter to misfire his shot and still score. Generally, the optimal, most forgiving arcs are between 43 degrees and 50 degrees.

Arc Skill Level

As discussed above, an accidental arc change of 1 degree in either direction (a total range of 2 degrees) on a high arc shot can cause the ball to rim out. Noah Basketball needed to learn whether it was difficult for an athlete to keep his arcs within a 2 degree range. After measuring thousands of Noah sessions, we learned that only 1 percent of the basketball

playing athletes can control their arc to this level of accuracy. The rest of us have a large amount of variation in shot arcs which often keeps the ball from scoring.

Noah Basketball has defined a term called *Arc Skill Level* which measures how well a shooter can control their arc. As shown in Figure 9, the Arc Skill Levels range from Builder to Master, with the very highest performance at the top of the scale. An Arc Skill Level of Master IV is perfect and means that a shooter can shoot 25 shots in a row with exactly the same arc. So far this perfect Arc Skill Level has never been achieved. The best Arc Skill Level measured to date is Master II and has been demonstrated by some of the very best professional and college athletes. On the other end of the scale, a skill level of Builder I demonstrates only minimal control. Table 1 shows typical Arc Skill Level scores for a variety of leagues.



A shooter's Arc Skill Level is closely tied to his *Scoring Percentage*, meaning the percentage of shots that go through the hoop. This relationship between Arc Skill Level and Scoring Percentage has been shown in scientific studies, theoretical analysis and in game box scores. Let us review an example to show the importance of Arc Skill Level.

Example A: A high school player shoots a free throw with women's ball from a release height of 6 feet with an average arc of 50 degrees. This player has an Arc Skill Level of Maker III and a game free throw percentage of 65%. Holding all other factors constant (fatigue, nervousness, direction control), the shooter's game free throw percentage will increase as shown in the table below.

Arc Skill Level	Maker MakeIII	Expert I	Expert III	Master I
Scoring %	65%	70%	77%	87%

Real World Examples

Chris Mullin, former NBA All-Star and Noah Basketball Advisory Board Member, is an example of an excellent shooter with a high Arc Skill Level. Photo 3 shows the arcs of 25 shots that Chris took from Pro 3-point range. The orange lines on the photo show the area where the arcs are most different from each other. Notice that each of these shots follows nearly the identical arc from Chris' hand to the hoop. Chris made 24 of 25 shots during this session and achieved an impressive Arc Skill Level score of Master I.

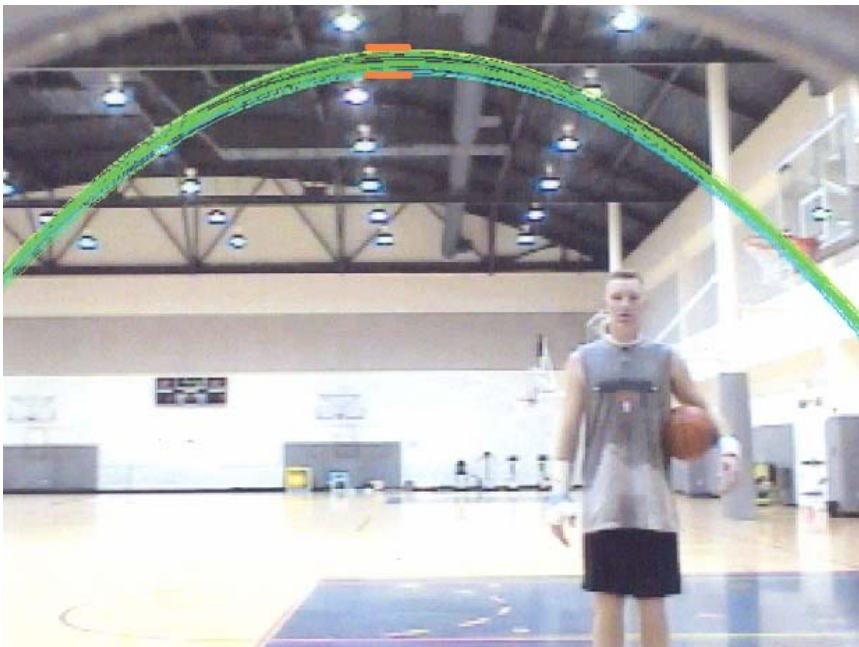


Photo 3
Chris Mullin
Plot of 25 Shot Arcs
Master I Skill Level

Now let us compare the path of Chris Mullin's 25 shots with those of an 8th Grade point guard shown in Photo 4. The orange lines in Photo 4 show the area where the arcs are most different from each other. The arcs of these 25 shots are typical of a middle school athlete and represent an Arc Skill Level of Shooter II. The shooter made 11 of 25 shots (44%).

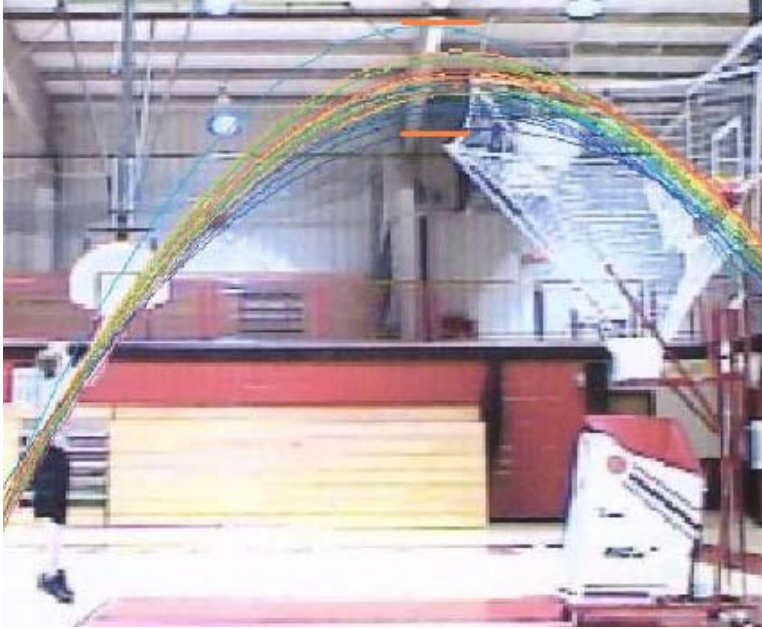


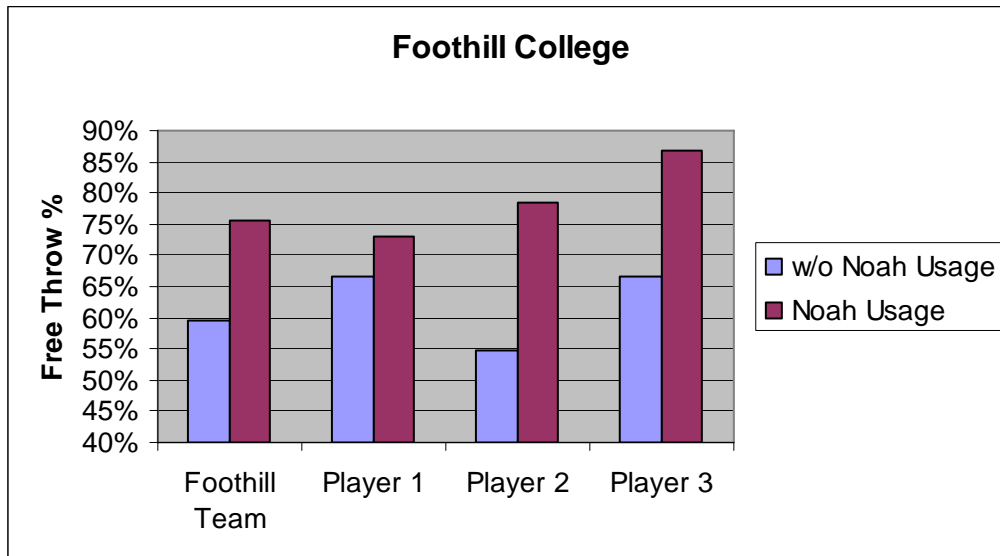
Photo 4
Middle School Shooter
Day One
Plot of 25 Shot Arcs
Shooter II Skill Level

This 8th Grade point guard practiced shooting free throws with Noah instant verbal arc feedback on three days over a two week period. During every Noah practice session, he tried to achieve a 45 degree arc on every shot. The first practice day he took 75 shots with Noah feedback and improved his Arc Skill Level to Maker I while shooting 60%. The second practice day he took 100 shots with Noah feedback and improved his Arc Skill Level to Maker II while shooting 64%. The third practice day the shooter was so excited about his improvement using Noah that it was hard to get him to stop shooting. He took 200 free throw shots with Noah feedback and improved his Arc Skill Level to Maker III while shooting 78%. The orange lines in Photo 5 show the area where the arcs are most different from each other. Notice the difference in the spacing of the orange lines from Photo 4 to Photo 5. The arc consistency was dramatically improved in only three days of practice and the shooting percentage increased from 44% to 78%.



Photo 5
 Middle School Shooter
 Day Three
 Plot of 25 Shot Arcs
 Maker IV Skill Level

Noah based practice will also enable rapid, significant shooting improvement for an entire basketball team. As an example, the Foothill College women’s basketball team was only able to use their Noah system for half of the 2003-2004 basketball season. During this season, the coaches and players were unchanged. As you can see in the chart below, while using Noah in practice, the players shot an average of 17% better in their games (77% v. 60%). The players who used Noah the most showed the most change, with one player showing a 23% change.



Summary

Coaches and shooters have known for many years that arc was important to consistent scoring, but serious training for the arc has never been possible. As a result, many promising athletes have not performed up to their scoring potential. Using the Noah system of instant verbal arc feedback, athletes at any level can perfect their arc consistency and Arc Skill Level at a rapid pace, resulting in deeply ingrained muscle memory and more points scored.

For more information about the Noah System call 1-888-try-noah or visit the website at www.noahbasketball.com.