How Technology Has Changed the Game of Golf

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Editor's Note: *Katie wrote this paper as part of an independent study conducted with Dr. Wayne Kussow. A former member of the UW women's golf team, Katie is now playing on the Futures Tour.*

How can a game that involves a player, a club, a ball, and a hole look so simple, yet be so heavily driven by technology? As we watch Tiger blast drives over 300 yards down the fairway and Ernie Els nonchalantly shoot thirty-one under par to set a new tournament record, we assume that it they can do it, so can we. With all the choices of golf clubs and golf balls and each one of them being touted as the latest, greatest technological advance, how can one not play as well as Tiger or any other tour player?

For centuries, the game of golf has been evolving at a steady rate with technological advancements in all aspects of the game: golf course architecture, maintenance, clubs, balls, teaching, and even players. However, at the 1997 Masters, the evolution of golf was stimulated by the record-breaking performance of Tiger Woods. Tiger "raised the bar" for both performance and the expectations of golfers, which in turn, has positively influenced the new wave of golf technology that has been developed in the past few years.

As Tiger demolished the field by a 12-shot margin of victory at 18 under par, the world of golf was both amazed and shocked. Golf had not witnessed this kind of accomplishment for more than two decades past since the era of Jack Nicklaus. How could someone so new to the game win a major by such a large margin over everyone else? Instead of honoring the great performance of Tiger, the world of golf introduced the idea of "Tiger-proofing" to prevent anything like this from ever occurring again. The ideas of "Tiger-proofing" were to make courses longer and more difficult, put restrictions on clubs and balls, and basically prevent longer, better players like Tiger from ever winning any tournament by such a large margin again. "Tiger-

proofing" was meant to protect the history of the game, when in fact, it sparked one of the greatest technological advancements in the history of the game.

Golfers wanted longer courses and instead of the normal yardage of 6500 yards for a golf course, the public expected courses of a minimum of 7000 yards. The general consensus was that the longer the course, the more difficult it would be for the longer players, but in actuality this idea would backfire by only punishing the average golfer. When courses are lengthened and "tricked up," this actually benefits the longer hitters because they tend to be the better players and the better players are the more accurate players. Therefore, to meet the demands and higher expectations of golfers, golf course architects reviewed courses and implemented new designs to lengthen already existing courses and develop more difficult courses.

Today, the new ideas and features of golf course design are not meant to penalize the golfer, but to meet the newly instilled demands of the game of golf. To accommodate for the elasticity in length of different golfers, more tees can be made for golfers to have a wider range of tee selection to choose from that conforms to their own games. Besides making more tees, courses can narrow tee shot landing areas in the fairways and strategically place hazards in or near the landing areas to place a greater emphasis on accuracy. There are also many options when designing the greens because the axis, depth/size, and contouring of the greens can demand more accuracy as well. With all of these improvements and changes in golf course design, there comes a cost and an increase in acreage requirements. There are increases in land acquisition costs, construction costs, and maintenance costs. Another question raised is who absorbs these costs?

With all of the new features of golf course design, one of the most important factors/ideas that golf course architects consider is that as the ball goes farther, the more likely it will go sideways. With greater chances of the ball going sideways, safety becomes a major issue because the need for more separation between golf holes is a must. On an already existing course that consists of 50 acres, this can be tough to accommodate because of the little space to work with. Courses with limited space can strategically place more hazards into its shorter layout and make adjustments in maintenance practices and irrigation to demand accuracy from its players.

Maintenance practices are also changing with the progression of the game of golf. In an effort to parallel technology and the advancement of the game, courses are making greens faster, heightening the roughs in narrower landing areas, softening sand in the bunkers, and adding mounds to inflict awkward lies. Faster greens are a major issue for golfers because the quickness tests the true ability of the player. Instead of using riding mowers that tend to exert 75 pounds, more courses are utilizing walking mowers, which exert 225 pounds to help increase the speed of the greens. When a heavier mass is rolling across the green while cutting them, the grass is compressed to make a firmer, quicker putting surface.

Another method used to increase the speed of greens is to use a growth retardant to slow down or decrease the amount of grass that grows. Using less irrigation on the greens will dry them out, and putting sand on the greens will make the putting surface firmer to implement faster greens. Superintendents also credit the discontinued use of metal spikes to better, smoother putting surfaces.

As the demands are met for longer and more difficult courses, the demand for new, improved clubs and balls is inevitable. When golf started out, and for centuries after, golf clubs were all made of wood. At a fairly leisurely pace, other materials began to be used for both the heads and the shafts. There were fiberglass shafts, aluminum shafts, and steel shafts. Club heads eventually began to be made out of both wood (hence, "woods") and steel (hence, "irons"). But in recent years, more and more exotic materials have been used. Today, the most popular material for

golf club heads, both woods and irons, is titanium. Titanium is both light and strong - so light that club heads can be made larger than they have even been before, while still meeting golf regulations regarding club head weight. A large club head gives the golfer a larger "sweet spot" because it is at the spot that the club is perfectly balanced and will send the ball in the air most efficiently.

Titanium is so light, that other, heavier metals such as tungsten or brass, must be added to the irons to give them the right weight. Golf club manufacturers take advantage of this by carefully positioning the additional metals at the center of gravity where they feel it will be the most beneficial during the swing. Strength and lightweight are what have also brought graphite into the forefront as the material of choice for golf club shafts. Steel shafts, on the other hand, used to be nearly impossible to break or bend due to their heaviness and durability. If the steel shaft was bent, it could be twisted and bent back into place to be used again like normal because the shafts were so thick. Today, manufacturers extrude the steel shaft to make the walls thinner, while using stronger materials to make the shafts lighter. A lighter shaft means a faster swing, and more energy transferred to the ball.

A good golfer can achieve a club head speed of 100 miles per hour. When the club hits the ball, the ball flattens, losing a third of its diameter. The club head, no matter what it is made out of, is much harder than the ball and does not change shape; instead, it loses speed, going from 100 miles per our to just 81 miles per hour. The missing 19 miles per hour worth of energy is transferred to the compressed ball. Naturally, the compressed ball does not remain compressed long. It very quickly springs back into shape, pushing backward onto the club head at the same time. That push slows down the club even more - to about 70 miles per hour - and speeds up the ball, so that the ball will fly away from that 100-mile-per-hour swing at a massive 135 miles per hour. How far and how fast you hit a golf ball depends not only on your swing and on the club, but also on the ball itself.

The first golf balls were feather-stuffed leather bags called "featheries." They were soon replaced by gutta-percha balls, made of dried gum from the Malaysian sapodilla tree. After that came solid, one-piece rubber balls, then two-piece rubber balls, which have solid rubber interiors and plastic or balata covers. Finally came three-piece balls that consist of a small, solid

core wound with runner thread and covered with plastic or balata.

These different materials dramatically affect how far and how fast the ball flies. A ball gets more speed if it decompresses faster after being hit by a club, which can also affect how straight it travels. Yet, manufacturers cannot just create balls that fly as far and as fast as possible, because the U.S. Golf Association has specified for mor than 50 years that a golf ball propelled under certain specified conditions should travel about 250 yards at a speed of no more than 250 feet per second. If they want to sell their balls, manufacturers have to make sure they meet regulations. It would be fairly easy to create a ball that could be hit, say 400 yards, but that would destabilize the game so much that it could never be allowed.

Within the regulations, however, there has been lots of room for innovations. Three-piece balls, for example, have given manufacturers opportunity to experiment with dozens of different core materials. Golf ball centers have been made of steel, glass, rubber, silicone, dry ice, tapioca, and iodine, to name just a few. Whatever the material, it is usually frozen so that it maintains a perfectly spherical shape while about 30 yards of rubber is wound tightly around it, exerting a pressure of 2500 pounds per square inch. Titanium, which is very popular with golf club heads, has even found its way into golf ball centers. Titanium powder supposedly acts as a kind of glue to hold the other core components in place, which in turn, is supposed to transfer more energy from the ball to the club face at impact due to less compression (the goal of all core materials).

Another innovation is the four-piece golf ball, with a solid core, rubber windings, a soft inner cover, and a soft outer cover. These balls are supposed to react differently depending on how fast your swing speed is. Hit it easy, and only the outer cover is affected, so the shot feels soft; hit it hard, and both covers come into play, providing distance.

One of the most notable features of a golf ball is the dimples. Simply put, dimples make the golf balls fly farther. As a smooth ball flies through the atmosphere, it leaves a partial vacuum in its wake. This pulls at the ball, reducing its speed so that it drops to the ground much sooner than it would if it were hit in a vacuum. The dimples capture air, so that the ball is wrapped in its own atmosphere. Instead of leaving a partial vacuum behind it, it just leaves a stream of more air, which reduces drag and lets the ball fly farther.

The ideal diameter for dimples, if the goal is flight-worthiness, is about 0.15 inch. Disperse those evenly over the surface of a golf ball and it gives you about 336 of them. That was the standard for decades, but recently, manufacturers heave realized that the size of the dimples can be varied by a 1/100th or 2/100th of an inch, which gives the ball more dimples. As a result, some golf balls have 400 or even 500 dimples, and

dimple configurations are constantly being tested using wind-tunnels just like the ones used to test airplane designs, only smaller and not as windy. Dimple arrangements on the balls can even be varied in size and dispersion throughout the ball like the new Pro-VIX ball that has made its way onto the PGA Tour, giving players up to an extra 20 yards.

With all of this new technology in golf clubs and golf balls, the teaching aspect of the game changes as well. Due to the variation in hardness of golf balls, the need to develop swing speed to hit the ball becomes very important. A golfer can have all the top of the line equipment, but if they do not have the swing speed, the ball will not go its maximum yardage. Arm and hand speed are needed to get the maximum yardage out of the swing. Teachers emphasize getting the club in the correct plane, which in turn will position the club on the correct angle of attack to meet the ball square with the club face. By judging the shape, trajectory, and curvature of the ball flight, teachers can determine what needs to be adjusted or corrected to attain the best ball flight.

Golfers have different swings and swing speeds, and with new technology, clubs can be designed to match player's swings to maximize distance, consistency, and accuracy. Depending on the swing speed of the individual, the shaft can be adjusted to produce more club head speed. Shafts can be comprised of steel or graphite, and the latest development is the combination of both graphite and steel in the same shaft. Typically, someone with a lower swing speed would need a lighter shaft with less stiffness and someone with a higher swing speed would need a heavier shaft with more stiffness.

Club heads have also been adjusted with the new cavity-backed clubs and the principle of perimeter weighting. Cavity-backed clubs are designed to be more forgiving because the off-center strikes will travel straighter and longer than was previously possible with older technology. These clubs do this by having the weight taken from the back of the club head and placed around the perimeter - hence perimeter weighting. Because the club head has this weight behind the toe and heel of the club, when a shot is hit from either, the head remains more stable and does not twist. Anything that reduces twist in the club head at impact will result in more accurate, longer shots. Cavity-backed clubs now also tend to have lower centers of gravity to produce a higher launch angle for shots, which allows the ball to get airborne more easily. This makes hitting long irons considerably easier and less daunting.

With improvements in player swings and equipment, handicaps are decreasing. Golfers can now hit more greens and reach greens that they could not in years past. This means that they are getting strokes on the greens because if a player with a high handicap is hitting the same amount of greens as a player with a lower handicap, the higher handicapper is getting more strokes based on their handicap. To fix this, courses are utilizing four to five different tees with different course ratings to establish a handicap based on the tees an individual regularly plays.

Besides changes in equipment, courses, and teaching, the players themselves are changing. Today, conditioning for golf is more important than ever before to improve performance and prevent injuries. There are more golf-specific stretches and exercises being promoted, when less than 10 years ago, it was rare to hear or see any information regarding conditioning for golf. Conditioning for golf was unheard of because golf was not considered an athletic sport, but it has become a key element to success of many tour players. Annika Sorenstam credits her captivating 2001 season, which featured eight victories, a 59, and LPGA Tour records for earnings and scoring average, to a strict exercise program she intensified in late 2000. David Duval, who started 1999 with a 59 of his own and a burst of victories that seized the No. 1 ranking from Tiger Woods, radically changed his body with a killer off-season program before the 2000 season. Tiger Woods himself was transforming his own swing and upgrading his training and nutrition, to lay the groundwork for what would become the finest 18-month run in golf history.

From watching players like Annika Sorenstam, David Duval, and Tiger Woods, the golfing world is realizing that a more fit and flexible body plays amazingly better golf. Golf is a game of endurance, strength, and flexibility, and with the right kind of stretches, exercises, and diet, golfers can keep their golf-specific muscles lean and powerful to guarantee optimum performance. The golf swing is an extremely high-speed, torquing movement that demands optimal muscular strength in the abdominal muscles and lower back. Yoga and pilates are programs that are become more popular among golfers because of their great emphasis on flexibility in golf-specific muscles. A healthy diet is also an important factor that a golfer must maintain to promote optimum performance.

Today, there are approximately 17,000 patents for new golf products. First, it was oversized club heads and long-distance balls. Now it's golf assisted by satellites. The global positioning system employed during the Gulf War is now being used to track the position of specifically equipped golf carts. This allows golfers to gauge the distance from the tee to the hole. But the GPS does not just read the layout of the course - it can tell a golfer about an approaching lightening storm and even order lunch. Golfers can also use the system to call for help in case of an emergency. A most recent innovation is the use of binoculars with a laser beam that detects reflectors in or on top of the flag sticks to tell a golfer exactly how far they are from the pin for each shot. Another new invention allows golfers to step into a videotaped silhouette of a professional golfer and then imitate the pro's swing. On the driving range, average golfers can compare their swings to those of the professionals.

The latest innovations in both clubs and balls continue to make golf easier and more accessible for more and more people, which is one reason why the sport is so popular. PGA tour players are basking in the new technology of equipment because it is allowing the middle players to compete with the best. Players who are not as long off the tee like Jeff Sluman, Mike Wier, and Fred Funk can now compete with the longer hitters with the advantages of new technology. Driving distance, fairways in regulation, and greens in regulation have all increased within the past 20 years as a result of the new technology (see table below).

Average of top 10 PGA	1982	1992	2002	2003
Driving distance	270 yards	275 yards	298 yards	302 yards
Fairways in regulation	73%	73%	73%	75%
Greens in regulation	71%	71%	71%	76%

In fact, this year at the Phoenix Open, the field averaged 301.3 yards off the tee. In 1993, the longest drive to date was 388 yards, and in 2003, at the height of technology, the longest drive to date is 446 yards.

Technology has impacted golf course design, maintenance practices, clubs and balls, teaching, and the players themselves. Golf course design features include more tees, narrower tee shot landing areas, strategically placed hazards, and more contouring on the greens. Courses are also being maintained differently with the utilization of better equipment designed to increase green speed. Clubs are now designed to match player's swings and maximize distance, consistency, and accuracy. Dimple arrangements on balls are being dispersed and varied to reduce drag and let the ball fly further. Finally, players themselves are discovering how important conditioning and a healthy diet are for optimum performance. In 1997, the evolution of the game of golf was stimulated by the performance of Tiger Woods. Who would have thought that the performance of one man would lead to the most incredible advancement the game of golf has ever witnessed?