

Mixed Reality Cue Sports Training Aid

Executive Summary

The following report outlines a start-up opportunity for a new, premium training tool for cue sports, such as pool and snooker. Utilising Mixed Reality technology, we aim to produce and provide a new software system for a Head Mounted Display, such as the Microsoft HoloLens, to reduce the time taken for beginner and amateur cue sports players to improve their game skills. These skills range from potting accuracy to positioning of game balls. The system is targeted towards individuals with a high disposable income who will be able to buy it either directly from our website or through an affiliated distributor. We also aim to sell our system to existing pool and snooker halls to expand upon their current equipment.

For this system, we have begun development of a bespoke software system, but this needs finalising and additional user testing before release. Further development will include staged feature implementation, user testing, and quality assurance testing to ensure our product is ready for release. We aim to secure a capital investment of £300,000 which will allow us to finish system development, before marketing and launching the system initially in the UK market, with plans to expand into the Chinese market in the near future. A partnership with a headset manufacturer, such as Microsoft, would also be beneficial to reduce the product cost and overhead of the physical hardware our system is based upon.

Evaluation of Potential Opportunity

Although having a low entry curve to the sport, with many people having played casually in a pub or a pool hall, cue sports, such as pool and snooker, can be one of the most challenging and time-consuming sports to improve upon and become good at – even at an amateur level. Training requires countless hours of individual work in order to see any improvement, or even to become consistent in your ability, and is often neglected by casual and amateur players. There are many aspects to the game which require training, as indicated by my interview with the previous president of the University of Bristol Pool and Snooker Cub (see Appendix A). These include potting, cue ball positioning, break building, and complex/spin shots to name a few. Individually, these skills all require a huge time commitment to improve upon, and this is before playing any games against people which is vital for skill development²⁰. However, the backbone of the sport, and most important skill to develop, is consistently hitting and potting balls accurately^(Appendix A, Q4).

In terms of developing said skills, there are currently only a few options at present. Firstly, you can perform templated potting and technique training drills⁶, but this method provides no real feedback on what you are doing incorrectly, nor does it provide any guidance on aiming or technique. Secondly, you can pay for a professional coach who will give form and technique feedback, but you will still require many hours of practice outside of these sessions to improve and develop, not to mention being expensive – up to £120 per hour in some cases¹⁴. Additionally, many hours of game time will also be required in order to combine these skills correctly and effectively¹⁵. As a whole, current training standards for cue sports are time consuming and can be expensive, especially for beginner and amateur players.

Through the training methods previously described, a lot of repetition and trial-and-error is needed to improve, even for somewhat competent players. With most people only wanting to play with their friends in a casual setting, only those who compete at a club level or higher will currently take the time to properly practice and train. Reducing the time commitment needed to improve would allow new and amateur players to win against their friends and get more enjoyment from playing the sport, but without having to commit to time hungry training. This would be a huge benefit for those with full time jobs and families who do not have a large amount of time for training.

Furthermore, development of a new system that reduces the amount of time a player takes to improve would certainly see an increase in the popularity of the sport. Many people who have played pool or snooker before are often intimidated or unwilling to play due to their lack of skill and not getting the gratification of winning or even potting a ball. Creation of such a tool that allows a user to improve their accuracy more quickly would decrease this barrier cue sports currently faces, making the sport more popular and enjoyable for new, casual, and amateur players. Thusly, we see our target demographic to be new, casual, and amateur cue sports players, rather than people who compete at a club, semi-professional, or professional level who are willing to commit a lot of time to developing their skill level.

Due to the high price of the HMDs the system uses, our target audience should also be focused on people with a high disposable income. Approximately 2.25 million gaming enthusiasts currently have their own VR equipment^{4,11}, so we can see that consumers are willing to pay for new emerging technologies, despite their high price tag. However, as mixed reality headset technology improves and competition between companies increases, we should see a decrease in headset cost. Already, we can see competition emerging between companies such as Microsoft, Google, Epson, all of which have released their own mixed reality head mounted displays¹³. With reduced cost and wider availability, we will be able to widen our target demographic to people with less disposable income.

Additionally, existing high-end snooker and pool halls where the clientele will expect the newest and best equipment, such as the Northern Snooker Centre in Leeds⁹, could be a valuable extension of our client base. Targeting such establishments would increase brand and product exposure within their client base for free, as well as allowing consumers to try the product before they buy it, reducing the chance for unhappy customers or product returns.

With cue sports becoming increasingly popular, it is vital that action is taken now in order to succeed with this opportunity. Snooker especially is beginning to regain the national popularity that it had back in the 1980s, with over 25% (17.1 million)⁵ of the UK population (66.8 million)¹⁰ having watched the 2020 World Snooker Championship Final - up from 11.8 million in 2019⁵. Additionally, over recent years snooker has soared in popularity in China, largely down to government funding and recent successes of professional players such as Li Hang, Marco Fu, and Ding Junhui^{17,18}. With the majority of amateur players in China being white-collar workers between ages 16-35¹⁷, entering into the Chinese market would undoubtedly see an increase in demand for our system, as this perfectly fits in with our target demographic. Furthermore, there have been recent attempts by the World Confederation of Billiards to have snooker included in the sports played at the Olympic games¹, with hope that a 2028 bid will be successful, again showing that snooker especially is gaining popularity world-wide.

When it comes to the technology the system will use, the Mixed Reality (MR) market is set to be one of the fastest growing over the next five years, with the market valued at \$553 million in 2020 and set to rise to over \$5.81 billion by 2026³. The gaming and entertainment sectors are set to be the major driving force behind the MR market's growth³, so entering into this MR market sector would allow us to contribute and benefit greatly from the market's projected success. Looking at similar technologies, the Virtual Reality (VR) market was valued at \$17.25 billion in 2020 and set to rise to over \$184.66 billion by 2026². A big driving force of current VR market growth has similarly come from the gaming and entertainment sector, showing there is proven success and large growth within an alike technology focused market sector to the one we will be entering.

Value Proposition

Our idea for a new and innovative training tool for amateur cue sports players is to overlay helpful, interactive graphics onto the playing table. These graphics will help improve a player's hitting and potting accuracy more efficiently than current training methods, as well as bringing added excitement

to their game. Utilising computer vision techniques, in combination the HoloLens headset, we can seamlessly overlay 3D models, graphics, text and more over the top of any surface for only the headset wearer to see; much like a science fiction hologram. Prior to playing, the user must first calibrate the system to the playing table. This is easily done by placing QR codes on each corner of the table and then scanning them with our custom-built calibration tool on the HoloLens headset. Once this is done, the user can begin playing, aided of course by our integrated training tool set. For our system, we have chosen to implement the following features which we believe will best benefit the user in their training:

- **Aiming lines** (such as in Figure 1^(Appendix C)) - Showing the user the trajectory of the cue ball, including the paths after any collisions with cushions or other balls, will help a user to increase their accuracy in hitting and potting target balls. Long term, this tool will help the user quickly learn where to aim and hit the cue ball when trying to pot another ball, compared to the trial-and-error guess work that most new and amateur players must employ to develop their aim.
- **Session statistics** (As suggested in Appendix A, Q6) - such as pots made, hit percentage, and average time per shot, these statistics will allow users to track their progress over time and visually see their improvement.
- **A 'snapshot' function** (As suggested in Appendix A, Q6) - allows players to easily reset the ball positions exactly to practice the same shot consistently. This is especially useful for complicated or difficult shots that they wish to target in their training, or for quickly and reliably setting up various training drills.
- **Next shot indicator** – An indicator to suggest the next best ball to play in a game situation will help teach the user game sense and improve their decision making whilst playing – another crucial skill area to develop that is difficult to do when playing/training on your own.

We can be sure our product will improve a user's long-term accuracy quicker than existing solutions for several reasons. Firstly, and most importantly, the user will most likely be using the device whilst performing standard training drills we talked about earlier. This means that at the very least, they will be gaining as much as they would be if they did not train using our headset. Secondly, using our current mid-development system, initial user testing (conducted on 6 people with very little prior playing experience) has shown a user's accuracy to increase at a quicker rate compared to current training methodologies. Our results showed an approximately 85%^(Appendix D, Table 1) average increase in pre-set shot accuracy when wearing our headset compared to the user playing the same shots without our headset. Additionally, an approximately 50%^(Appendix D, Table 2) increase in long-term shot accuracy without headset use was seen 5 days after user's performed three 30-minute training sessions using our system across one week. This is compared to an approximately 15%^(Appendix D, Table 2) increase in long-term shot accuracy without headset use after the same three 30-minute training sessions, but without using our system. Furthermore, from existing research in Augmented Reality (AR) assisted sports training¹⁹, we can see that AR type technologies can be utilised and combined with traditional sports training to improve a person's ability more effectively.

Looking towards alternative, similar solutions, our closest competitor would be a product such as Pool Live AR¹². As seen in Figure 2^(Appendix C), their solution also projects graphics onto the playing table to aid in a player's aiming of the cue ball. However, it is unclear what other features their system possesses or whether it has been tested as a useful, time-saving training tool, or if the projected graphics are more of a gimmick. In this aspect, our solution carries an advantage over Pool Live AR, due to the extended feature set we provided, as well as our promising initial test data showing its time-saving value to beginner and amateur players. Additionally, Pool Live AR's solution is integrated into a specialised table and requires mounting additional hardware (such as a camera and projector) above the play table. This limits where the system can be used and makes it extremely immobile. Again, our solution is self-contained within the Microsoft HoloLens headset, allowing a user to easily use the

system on any pool or snooker table after a quick and easy calibration process. Furthermore, Pool Live AR does not seem to be commercially available. The closest product on the market to Pool Live AR or our product is the iPool Projector⁸ which projects visual graphics onto a pool table's surface. However, these are only visual enhancements rather than training or performance aids and are only available at wholesale on request. Therefore, our system, upon release, would be a first in the market sector with very little close competition.

Despite this, we can see a few drawbacks to our system when compared to other solutions. Firstly, other systems, including Pool Live AR, are seen to track the user's cue and display the ball's path lines according to the cue's position. Our solution does not do this and instead shows the user where they should strike the cue ball – resulting in a less intuitive user interface. Additionally, some user's may not want to wear a head mounted display whilst playing pool or snooker and could feel as though it is interfering with their play and training capabilities. More user feedback and testing is required in order to fully evaluate our system's user experience.

Impact Plan

Initially, we would be looking to secure a capital investment of £300,000 in return for a 20% stake in our company. This investment will help to continue and finalise development of the software solution required, allow us to undertake various stages of testing (including quality assurance), as well as market our product before launch. Ideally at this stage, we would also bring on an experienced CEO to handle business operations, whilst the roles of CTO and Chief Engineer can be fulfilled by existing staff who have extensive software development experience. We aim to launch into the UK market, with our product being available directly from us through our website, as well as external distributors such as Home Leisure Direct⁷ who already specialise in distributing high end cue sports equipment, such as luxury pool tables. Within approximately 2-years, we aim to then move into international distribution, especially targeting the growing Chinese snooker and pool market.

Additionally, to the capital investment, we aim to gain a partnership with Microsoft. Currently, the most technically sophisticated and well-polished mixed reality headsets are Microsoft's HoloLens Gen. 2, hence why they were chosen as the hardware base of our product. A successful partnership will allow us to attain headsets at a better price, whilst also allowing us to have access to new hardware and headset revisions quicker. This will give us an edge over any competition that may arise, allow us to increase our profit margins, decrease product cost for our customers, as well as giving our brand credibility due to its association with a high-profile company such as Microsoft.

In terms of our development plan, the system is currently in an alpha stage where most of our features have been implemented. However, extra work is still needed to ensure the system is error free, easily usable, and ready for commercial sale. We aim to achieve this by continuing our agile development strategy; meeting self-defined feature deadlines before testing and evaluating that feature, then making changes as necessary. Once we are content with our product, we will enter a beta stage of development. This includes undergoing quality assurance testing, as well as mass testing our system on a wide range of potential users to attain first-hand feedback on the feature set, user interface design, and discover any overlooked problems the system may have. After testing has concluded, we will make changes we see fit based on the feedback received, ensuring the product ready for launch.

In terms of a target timeline, we aim to complete alpha development by July 2021, and have completed our extensive user testing by October 2021. With time for making any minor changes, we aim to market and launch our product by mid-to-late November 2021, in time for the Christmas period. Although not required for product launch, a partnership with Microsoft will allow us to decrease the price of the system. This will allow us to broaden our target demographic and increase profit margins, and so will be sought after immediately along with an investor and CEO recruitment.

Appendix A – Interview Questions

Below are the interview questions I sent to the former president of the University of Bristol Pool and Snooker Club, along with their responses (in red). No identifiable or sensitive information was collected, and consent was received from the individual prior to asking the questions.

Question 1: Do you perform training drills either alone or with others?

- Yes
- No

Question 2: Do you think training drills are an important part of snooker and pool development?

- Yes
- No

Question 3: If you answered ‘YES’ to question 1 or question 2, what technique do you (focus on the most) / (think are the most important) when training? Please select all that apply

- Hitting the targeted ball
- Potting the targeted ball
- Positioning the cue ball optimally for the next shot
- Break building
- Safety shots
- Complex / Spin shots

Question 4: Which one skill do you believe is the most important to train and develop to see the most improvement?

- Hitting the targeted ball
- Potting the targeted ball
- Positioning the cue ball optimally for the next shot
- Break building
- Safety shots
- Complex / Spin shots

Question 5: Would you like the idea of using a head mounted display when training that provides feedback and guidance on your shots whilst you play?

- Yes
- No
- Maybe

Question 6: What features or visual guidance would you find useful for such a device to have?

I think it would be very useful to have some sort of memory function - take a snapshot of the table before taking a shot, so that if you want to replay the shot for some reason, you can set it up again exactly. I think another good feature would be some ability to record statistics, i.e. % long pot success, etc.

Question 7: What would you be willing to pay for such a device?

- £0-£250
- £250-£500
- £500-£1000
- £1000-£2500

- £2500-£5000
- £5000+

Question 8: Would you ever pay for pool or snooker training?

- I have in the past
- Yes
- No
- Maybe

Question 9: How much would you consider paying for training? (Per session)

- £0
- £0-£10
- £10-£20
- £20-£30
- £30-£40
- £40-£50
- £50+

Question 10: Would you ever go to a Virtual Reality arcade or Virtual Reality experience recreationally?

- I have in previously.
- I would like to.
- No

Question 11: How much do you think (per hour) a Virtual Reality arcade or Virtual Reality experience should cost?

- £10-£20
- £20-£30
- £30-£40
- £40-£50
- £50+

Question 12: Who do you think would benefit most from such a system? Please select all which apply.

- New players
- Amateur players
- Club players (Play regularly as part of a club)
- Semi-Professional players
- Professional players

Appendix B - Terminology

Below is some useful explanations of cue sports specific terminologies.

- **Snookering**
 - Forcing the cue ball into a position such that the opposing player cannot hit a valid object ball directly – meaning they must first hit a cushion before a valid object ball to avoid a foul.

Appendix C – Figures

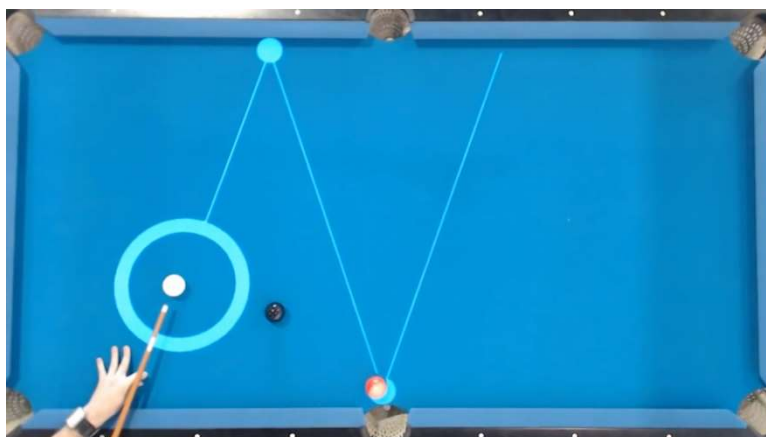


Figure 1 – Example of augmented graphic feature the headset would display¹⁶

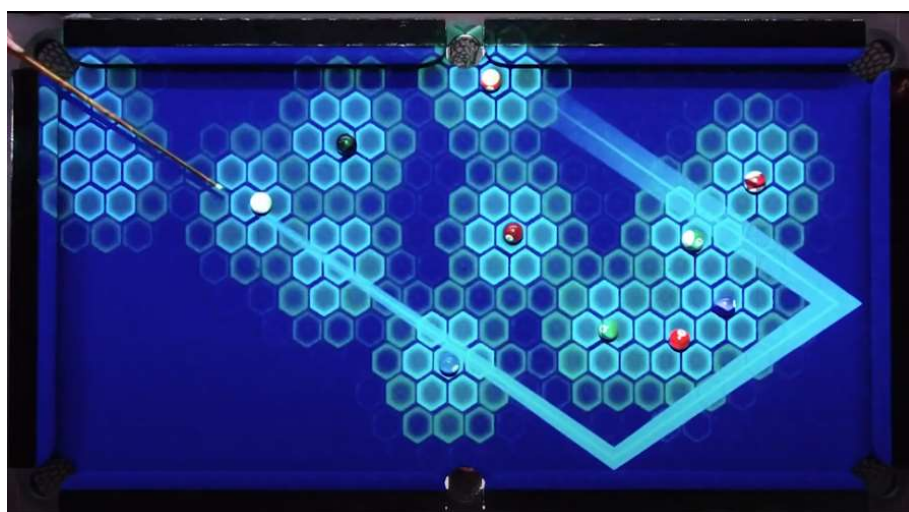


Figure 2 – Pool Live AR's product in use¹²

Appendix D – Preliminary User Testing Results

Table 1 (below) shows whether a user potted the target ball in each of 8 pre-set shots, both using our system, and not using our system. Green indicated that the user potted the target ball. Red indicates that they did not pot the target ball. The last 3 Rows shows the user's total potted with and without headset use, as well as difference between the two. Each of the users had very little prior cue sports experience and were given a 10-minute briefing/tutorial on how to use our system and the headset beforehand.

	User 1	User 2	User 3	User 4	User 5	User 6
Shot 1 With headset	Green	Green	Green	Red	Green	Green
Shot 1 Without headset	Green	Red	Red	Red	Red	Red
Shot 2 With headset	Green	Green	Green	Green	Green	Green

Shot 2 Without headset						
Shot 3 With headset						
Shot 3 Without headset						
Shot 4 With headset						
Shot 4 Without headset						
Shot 5 With headset						
Shot 5 Without headset						
Shot 6 With headset						
Shot 6 Without headset						
Shot 7 With headset						
Shot 7 Without headset						
Shot 8 With headset						
Shot 8 Without headset						
Without Headset pot success	12.5%	0%	12.5%	12.5%	0%	25%
With Headset pot success	100%	87.5%	100%	87.5%	100%	100%
% Increase	87.5%	87.5%	87.5%	75%	100%	75%

Table 2 (below) shows the shot success rate before three 30-minute training sessions performed over a week, and their shot accuracy 5 days after the last training session afterwards. Users 1-3 used our system in their 30-minute training sessions, whilst Users 4-6 did not use our headset whilst training.

Each of the users had very little prior cue sports experience and were given a 10-minute briefing/tutorial on how to use our system and the headset beforehand.

	User 1	User 2	User 3	User 4	User 5	User 6
Shot accuracy pre-training	9%	13%	6%	8%	16%	11%
Shot accuracy post training	51%	58%	63%	31%	43%	36%
% Increase	42%	45%	60%	12%	17%	15%

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