**Augmented Reality Snooker Training Aid: Start-Up Scoping Report**

***Executive Summary***

The following report outlines a start-up opportunity for a new, premium training tool for cue sports, such as pool, snooker, and billiards. Utilising Mixed Reality (MR) technologies, we aim to produce and provide a new system for wearable Head Mounted Display (HMD), such as the Microsoft HoloLens, to reduce the time taken for beginner and amateur cue sports players to improve their game skills, such as hitting, potting, or positioning game balls. The system is targeted towards individuals with a high disposable income who will be able to buy it either directly or through an affiliated distributor, as well as selling our system to existing pool and snooker halls to expand upon their current equipment.   
For this system, a bespoke software solution has begun development but needs finalising and additional user testing. This will include staged agile development, interim user testing, quality assurance, and finally a final product release. We aim to secure a capital investment which will allow us to continue 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 an HMD 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 playing casually in a pub or dedicated pool hall, cue sports can be one of the most challenging and time-consuming sports to improve upon and succeed at. Training often requires countless hours of individual work in order to improve and become consistent at. 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 (UoBPSC) (see Appendix A), such as potting, cue ball positioning, break building, and complex/spin shots. Individually, these skills require a huge time commitment to improve upon, and this is before playing any games against people which is vital for skill development(PRO\_SNOOK\_BLOG). However, the backbone of the sport, and most important skill to develop is hitting and potting balls accurately(Appendix A, Q4), thus our system will mainly focus on improving this skill in a more time efficient manner.

In terms of actually developing said skills, there are currently only a few options at present. First you can perform potting and technique training drills(CUE-DRILLS), but this method provides no real feedback on what you are doing incorrectly. Secondly, you can pay for a professional coach who will give form and technique feedback, but will still require many hours outside of these sessions to improve and develop, not to mention being expensive – up to £120 per hour in some cases(TERY-1TO1). Additionally, many hours of game time will also be required in order to combine these skills correctly and effectively.

New and amateur players tend to struggle most with consistently hitting and potting balls, as this takes a lot of time to develop due to their lack of experience. Through the training methods described above, a lot of repetition and trial-and-error is needed in order to improve and maintain this skill, even for somewhat competent players. With accuracy being the most important skill for a pool or snooker player to have, being able to develop this as quickly as possible will allow players to succeed in matches and improve the other aspects of their game much quicker and more easily. Therefore, this demographic is likely to see the most benefit from using our product, compared to semi-professional or even professional players who would already have good, consistent accuracy and would train in other areas of the game, such as cue-ball positioning or spin shots.

Due to the high price of the HMDs the system uses, our target demographic within new, amateur and frequent players should be focused people with a high disposable income, who may potentially have a private snooker/pool table or room. 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 display(SLANT). 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 or pool halls where the clientele will expect the newest and best equipment, such as the Northern Snooker Centre in Leeds(NORTHERN-SNOOK-CENTRE), 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 and returns.

With cue sports becoming as popular as ever, 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)(WST.TV) of the UK population (66.8 million)(OFFICE-NAT-STATS) having watched the 2020 World Snooker Championship Final; up from 11.8 million in 2019(WST.TV). Additionally, over recent years snooker has soared in popularity in China, largely down to government aid and the recent successes of professional players such as Li Hang, Marco Fu, and Ding Junhui(SHOCKPEDIA)(UNITED-LANGUAGE-GROUP). With the majority of amateur players in China being white-collar workers between ages 16-35(SHOCKPEDIA), entering into the Chinese market would undoubtably see an increase in demand for our system as this perfectly fits with our target audience. Furthermore, there have been recent attempts by the World Confederation of Billiards to have snooker included in the sports played at the Olympic games(BBC-SPORT-OLYMPIC), with hope that a 2028 bid will be successful, again showing that snooker especially is regaining 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 2026. The gaming and entertainment sectors are set to be the major driving force behind the MR market’s growth(MORDOR-MR), so entering into this MR market sector would allow us to contribute and benefit greatly from the market’s 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 2026(MORDOR-VR). A big driving force of the VR market growth has similarly come from the gaming and entertainment sector, meaning there is proven success and large growth within an alike market and sector to the one we will be entering.

Additionally, approximately 2.25 million gaming enthusiasts currently have their own VR equipment(STEAM)(STATISTA). With MR seeming set to follow a similar trend as VR in the coming years, we can see that consumers are willing to pay for new emerging technologies despite their high price tag. Acting now and establishing a brand at the start of the new technological trend will allow us to succeed and be most profitable, cementing our need to act now.

***Value Proposition***

A/B - 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 will improve and maintain a player’s hitting and potting accuracy more efficiently than current training methods. Utilising computer vision recognition 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 their training, 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 any collisions with cushions or other balls, and the paths post collision also, 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 user’s to track their progress over time and visually see their improvements
* **A ‘snapshot’ function** (As suggested in Appendix A, Q6) - allow 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 sometimes difficult to do when playing/training on your own.

C - 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 didn’t 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 resultsshowed an approximately 85%(Appendix D, Table 1) average increase in pre-set shot accuracy when wearing the headset compared to the user playing the same shots without the 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 25%(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 training(Stefani Palmieri), we can see the effectiveness of using AR within sports training, again, solidifying our findings of long-term user improvement after training with our system.

D – Looking towards alternative, similar solutions, our closest competitor would be a product such as Pool Live AR(POOL LIVE AR). As seen in Figure 2(Appendix C), their solution also projects helpful 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 provided, as well as 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. Despite this, we can see a few drawbacks to our system compared to others. 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 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 needed in order to fully evaluate the user experience. Despite our system’s drawbacks, Pool Live AR does not seem to be commercially available, nor any system similar. The closest product on the market is the iPool Projector(JOY BILLIARDS) 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 on request. Therefore, our system upon release would be a first in the market sector with very little close competition.

***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 a new experienced CEO to handle business operations, whilst the roles of CTO and Chief Engineer can be fulfilled by existing, experienced staff. We aim to launch in the UK market, with our product being available through our website and external distributors such as Home Leisure Direct(HOME LEISURE DIRECT) who already specialise in distributing luxury pool tables and equipment. After approximately 2-years, we aim to then move into international distribution, especially targeting the growing Chinese snooker market.

Ideally, 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 or headset revisions quickly. This will give us an edge over any competition that may arise, allow us to increase our profit margins, as well as giving our brand credibility due to its association with Microsoft.

In terms of development, the system is currently in an alpha stage where most of our features have been implemented, however extra work is 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 the feature, making changes as needed. Once we are content with our product, we will enter a beta stage of development. Here we will mass test our system on a wide range of potential users in order to attain first-hand feedback on the feature set, user interface design, and discover any overlooked problems within the system. After this testing, we will make changes we see fit based on the feedback received, making the product ready for launch.

In terms of a target timeline, we aim to complete development by June 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 early-December 2021, in time for the Christmas period. Although not required for 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 a capital investor / CEO.

***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+

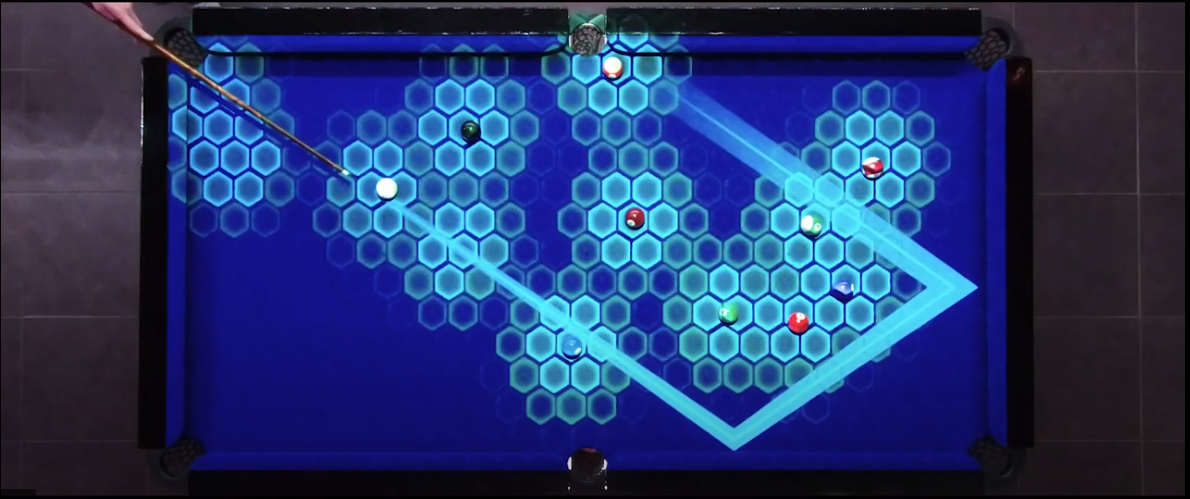
Question 12: Who do you think would benefit most from such a system? Please select all which apply.

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

***Appendix B - Terminology***

Below are 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.

Graphical user interface

Description automatically generated with medium confidence***Appendix C – Figures***

Figure 2 – Pool Live AR’s product in use

Figure 1 – Example of augmented graphic feature the headset would display. (MASHABLE)

***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 |  |  |  |  |  |  |
| **Shot 1** Without headset |  |  |  |  |  |  |
| **Shot 2** With headset |  |  |  |  |  |  |
| **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% | 23% | 27% | 25% |

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