World of Golf: A Socially Relevant Simulation Game

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ABSTRACT
Socially Relevant Simulation Games (SRSG), a new medium for social interaction, based on real-world skills and skill development, creates a single gaming framework that connects both serious and casual players. Through a detailed case study this paper presents a design process and framework for SRSG, in the context of mixed-reality golf swing simulations. The "World of Golf" SRSG utilizes a real-time expert system to capture, analyze, and evaluate golf swing metrics combining swing data with players' backgrounds, e.g., golf-handicaps, to form individual profiles. Simulation and assessment modules provide the serious player with tools to build golf skills while allowing casual players to engage within a simulated social world. A framework that incorporates simulated golf competitions among these social agents is presented and validated by comparing the usage statistics of 10 PGA Golf Management (PGM) students with 10 non-PGM students.

Author Keywords
Simulation, mixed reality, social gaming, real-time capture.

ACM Classification Keywords
I.6.8 [Simulation and Modeling]: Types of Simulation/ Gaming

General Terms
Serious Games, Social Games, Simulation, Sports.

INTRODUCTION
Game developers distinguish between realistic simulations, referred to as *serious games*, and games intended to incorporate social networks and interaction, referred to as *social games*. Most game designs fall into one category or the other. Consequently, each of these types of games tends to be adopted by a specific target audience. Despite the separate game development processes this distinction has created, it is possible to make a game socially relevant without losing the requirements of a simulation or serious game. This paper presents a design process based on the World of Golf [23] providing an in-depth case study that effectively blends the two forms to create Socially Relevant Simulation Games (SRSG).

In order to allow social and serious gaming elements to exist in parallel, SRSG implement a three-step design process, which includes simulation, uniform interfaces, and expansion, using social hooks. Using this design process, a SRSG begins as a simulation game, and acquires social relevancy through expansion using a social gaming module. We also present related background material that argues that there is evidence of the emerging integration of the two game categories, indicating examples of games which approach the overlap, but lack key elements critical in realizing the full potential of an SRSG. Previous work in both areas provides these elements, and we use them in the creation of a framework for the design process for SRSG. We then evaluate the SRSG framework, applying the design process to the creation of a prototype for a golf swing simulation game. We first observe the key golf swing metrics necessary to form an accurate assessment of a player's swing, and then incorporate these metrics in the creation of a swing simulation module. The interface for this prototype is designed to include features relevant to the audiences of both social and serious games. We expand this simulation using a "golf world" module in order to make it truly "socially relevant". We then evaluated our simulation, in order to validate that the simulation and gaming experiences accurately model real-world training and social interaction experiences. Finally we discuss the strengths and limitations of generalizing this approach.

BACKGROUND
Serious games and *social games* can be discussed in terms of a diverse range of parameters and contexts. To begin to understand the definition of these two categories of games, we might focus on the populations to which these categories of games appeal. Serious games target a niche community of experts or learners who specialize in the knowledge domain associated with the simulation [19], while social games target gamers who wish to connect with friends and family [10]. We define these categories through the characteristics and motivational factors present in their targeted audiences. SRSG combine elements that attend to both.

Serious Games
Serious games serve to educate, rather than entertain. Their primary purpose is to provide an interactive means by which a knowledge domain can be transferred to the player

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[19]. The audience for these games depends upon the subject matter present in the game. It consists of players who wish to train or learn a specific skill set, including experts and players who are already somewhat knowledgeable in the subject matter presented in the game, and often a serious game provides direct, visual means by which these players can assess themselves [27]. Many simulation games can thus be considered serious games [15]. Based on Moizer's work, we define a "serious game" as a game that: (1) is intended to educate or train the player; (2) contains a direct (usually visual) means of assessing skill or learning; and (3) employs a game interface providing the above two features.

Social Games

The goal of "social gaming" is to incorporate, as seamlessly as possible, the social interactions and networks, which occur in the real world in a virtual environment [26]. As such, the audience for social games includes players who wish to socialize and interact within this virtual environment [4, 10]. Social games may provide little benefit for single-player gameplay, and some may not include single-player functionality at all. Also, since the focus of a social game is on the social interaction, the game itself becomes a platform to facilitate this interaction [13], and thus the details of the game's subject matter are considered less significant. Facebook games are an example [11]. We define a "social game", or a game which is "socially relevant", as a game that: (1) requires little or no knowledge about the game's subject domain in order for a player to enjoy the game; and (2) employs an interface, central to enjoyment of the game that is designed to connect its player base through multi-player gameplay.

The Emerging Integration of Serious and Social Games

While some new games such as Microsoft Flight [14] order on the edge of being social simulations, none have truly adopted the structure required to interconnect the serious and the social audiences. Microsoft Flight has achieved a great deal as a simulation, and has the potential to expand into a social simulation. Games, such as Tiger Woods Golf are socially relevant [3], providing features, which cater to the casual player, but, due to the limited way in which they present the knowledge domain, and the limited control they give the user over his or her actions in the domain, are not considered simulations. Other games, such as America's Army, can be considered simulations [27] due to their realistic renditions of knowledge domains and the control given to the user to tap into the domain, but they lack social hooks necessary to make them socially relevant.

Game Domain: The Golf Swing

The SRSG design case study we present in this paper is a golfing game. We chose golf for this study since it is a subject domain in which skill can be visually assessed, and since it is a medium suitable for social interaction. We assess a golf player's skill from his or her golf swing. Previous work on golf swing analysis indicates that several valid metrics for swing assessment exist, each covering a variety of perspectives. Work by Ishii et al. targets the muscle strain on the player during the swing, emphasizing its effect on the club head path and rotation during the swing [8, 25]. Related work focuses on kinematic factors such as club speed and approach angle [3, 21, 22]. In addition to the swing metrics, several methods of swing analysis have been explored. A form of measurement applicable to games is the use of the 3-axis accelerometer [20]. Most modern gaming input controllers use an accelerometer to record three-dimensional motion input from the player, and this applies readily to the golf swing. The Wii remote, for example, has been proven useful in physics demonstrations [16], and since the remote contains a 3-axis accelerometer and a simple interface for both casual and expert players, we adopt it as a method of input.

A DESIGN FRAMEWORK

An SRSG design process has been developed that incorporates both the network-oriented interactivity of a social game and the learning and realism of a serious game into a single framework. The goal of this process is to remove the architectural barrier isolating the niche target serious audience from the niche casual audience while providing for the interests of each under a uniform interface. The interplay or marriage of the simulation-based learning element with the social network-based fun element is crucial in achieving this task. We have developed a framework for SRSG that includes a three-step design and development process, focusing simulation, uniform interfaces for all users, and social hooks (see Table 1).

Table 1. SRSG Design Framework: Key elements and successful examples of design approaches

Design Framework Steps	Key Design Elements	Successful approaches
Step 1: Simulation Design	Address expert audience needs Realistic simulation accurate to knowledge domain Accurate and precise measures (performance, skill, learning)	[18]
Step 2: Uniform Interface Design	Consistent between casual and expert players Informative for learning / simple for non-experts Experts can perceive improvement Casual inviting interface	[5, 9, 24]
Step 3: Social Hooks and Attractive Features	Address casual audience needs Facilitate social interactions Social Layer leverages Serious Layer / simulation	[1, 2, 7, 12, 17]

Step 1–Simulation Design: In this step the development team designs the simulation, or core serious game aspects, of the SRSG in a manner that ensures that it realistically and convincingly models the level of skill and domain knowledge of users. These elements of the serious game must remain intact in the design of the simulation elements

of the SRSG. This is critical in satisfying the interests of the highly informed niche audience. The simulation should include an accurate measure of performance, a way to assess skill and learning, and provide freedom to explore and interact with the simulation environment [27].

The design of a simulation is demonstrated in Raybourn's Simulation Experience Design method for creating adaptive training systems [18]. This method utilizes controlled simulation environments in which learning occurs through After-Action Review on the user's decisions in an in-game scenario. Since the goal of an adaptive training system is to train the user on how to react under various situations, it achieves the first key element in Step 1: to focus on the expert audience, in this case, the trainee. Scenarios in these systems are designed to replicate realistic scenarios, ensuring that serious elements remain intact in the gameplay. The interfaces of such systems are designed so that it is clear whether or not the player's decision in any given context is correct. Accordingly, the systems are able to make quantitative and qualitative assessments on the users' learning which are both precise and accurate.

Step 2–Uniform Interface Design: After completing Step 1, the development team must translate elements of the interface that has been developed to provide a consistent uniform interface, which is both informative and simple to understand for both casual and expert players. As expert players use the simulation, they should be able to rapidly perceive indications of progress and advancement. The feedback from the game to the user should encompass enough information to satisfy the learning needs of a serious player, while being simple enough and/or adaptively supportive so as not to confuse or overwhelm the casual, social player. The goal is not to isolate the two player bases, but rather to connect via uniform gameplay experience. The effectiveness of a consistent interface has been established in prior work by Häggström in the Real-Time Strategy genre, providing a simple mouse-click interface for casual players to enjoy the game without being overwhelmed by its complexity while allowing experts to utilize keyboard shortcuts to interact with game objects and tasks [5].

Step 3–Social Hooks and Attractive Features: Expand the completed simulation with social hooks and features to attract and entertain the casual audience. This step is perhaps the most challenging, and should take into careful consideration the interests of a casual audience. Social elements can be implemented as a layer on top of the core simulation engine using output from the simulation while providing a platform for social interaction and socially-driven gameplay [10]. Games such as Quest Atlantis [1] achieve these principles when data from the simulation becomes a back-end for entertaining gameplay, added atop the "serious layer" of the interface hooks such as networked virtual environments ("game worlds"), game avatars, and competitive matches. In Quest Atlantis this is done by immersing their users in a massively multiplayer virtual environment, and giving them a sense of "social responsibility". Players are given a presence in this environment through their avatars, and social interaction becomes key to completing quests and objectives. Social playability heuristics, such as SoPlay [17], can be used to evaluate and guide development of social interactions in games. Likewise researchers such as Isbister, Burleson and Picard [2, 7] have demonstrated effective ways of empirically evaluating a range of important social elements within games, gaming environments, and simulations.

WORLD OF GOLF

To demonstrate the efficacy of the SRSG design process we will describe the creation of World of Golf, as a generalizable SRSG. It is a golf swing simulation that includes a simple, yet powerful, method to facilitate online social gaming. It contains a combination of modules that provide both, a realistic real-time golf training experience for a professional golf audience and an engaging environment, facilitating interactions among a socially connected casual player base. We chose this subject domain because it includes easily measurable metrics of skill and performance and is an activity that facilitates social interaction among players. The design process applied to the domain of golf allowed for the creation of validated measures of skill (serious elements) and couple these to extracted mechanics and gameplay (casual elements) and embed these in the online simulation (see Figure 1).

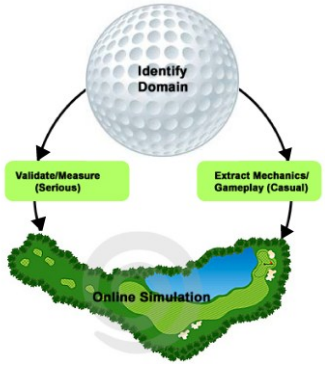

Figure 1: SRSG Design involves serious and casual elements in the context of online simulation

Step 1: Simulation Design

In order to create an accurate simulation and to complete the first step of our design process, we begin by establishing metrics that can serve as criteria for assessment and training. This process is critical for any simulation to be considered "serious", and the amount and types of metrics depend on the subject matter taught by the simulation. In our case, we are concerned strictly with the golf swing, and our metrics combined should help the player clearly differentiate between a proper swing and a poor swing.

Golf Swing Metrics

We chose the Wii remote as a method of input due to its simplicity of use and accessibility for both casual and

expert players. In general, metrics for the first step of the SRSG design process should be chosen based on two requirements: (1) the metrics should be accurately measurable using the chosen method of input; and (2) the metrics combined should form an accurate assessment of a player's skill level in the subject domain. Since the 3-axis accelerometer can readily detect changes in kinematic factors of a swing, we chose the metrics that could be detected by the Wii remote and provided a suitable assessment for expert players to use in their training. With these goals in mind, World of Golf 's game engine uses five golf swing metrics to determine what to look for in a player's golf swing. These are as follows:

Club Speed. As indicated in Figure 2, the vector representing the force acting upon the ball at time of collision, *v*-impact, is directly affected by the speed of forward motion with which the player swings [21].

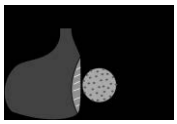

Figure 2: Club Speed

Club Face. The angle of the club head's face–open, closed or square–affects the direction of travel and curvature of the shot [25]. These three angles are indicated in Figure 3.

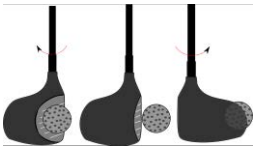

Figure 3: Club Face Rotations

Club Path. The path traveled by the club head during the swing influences direction of flight, which is directly proportional to club speed increments [22], see Figure 4.

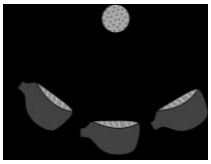

Figure 4: Club Paths

Centeredness at Contact. The distance travelled and direction of a ball are both influenced by how close the ball was to the club head's "sweet spot", see Figure 5.

Figure 5: Zones of Contact on Club Head

Angle of Approach. The steepness of the angle at which the club head approaches the ball during the swing affects how path distance and curvature [8], see Figure 6.

Figure 6: Club Angle of Approach

These five metrics interact to form a near-precise measure [22] of the flight path of the ball after contact and help satisfy the first step of the social simulation design process.

Swing Assessment and Feedback

The next step is to design an interface that brings the learning elements in the simulation to the player. In the general case, this includes both player input and feedback from the simulation. The goal is to visually represent metrics so that it is clear to the player through the interface how well he or she performed in the subject matter, and whether learning is taking place. By establishing this interface, we complete step 1 of the design process.

For this purpose, World of Golf utilizes real-time capture of 3-axis data from the Wiimote's accelerometer. The axes on the accelerometer are shown in Figure 7. The user holds the accelerometer with the y-axis pointing downward toward the ball and the z-axis facing in the direction opposite the shot. The x-axis represents the displacement of the club handle toward or away from the golfer.

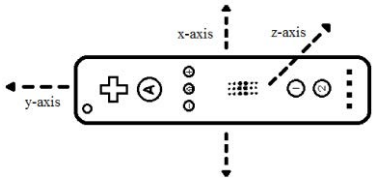

Figure 7: Wiimote Accelerometer Axes

The club then forms a "swing plane" which intersects a "ground plane" to represent a club path, as indicated in Figure 8. Deviations from this plane by the club head result in changes to the centeredness of contact, and a different club path results in a new swing plane altogether.

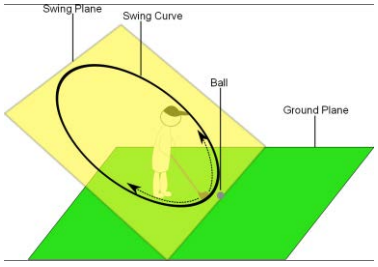

Figure 8: Planar Swing Model

The speed of the club head corresponds to the acceleration acting upon the z-axis throughout the swing, and rotations along the x-z plane represent rotations of the wrist, which causes changes in the club face angle. The angle of approach is the angle formed between the initial club shaft position and the current club shaft position.

Step 2: Uniform Interface Design

Having completed the first step, we now arrive at the second part of the SRSG design process, the development of a uniform interface, which includes features targeting both expert and casual audiences. In general, the interface for a SRSG should be designed so that, while some elements target expert audiences and some focus on casual audiences, all elements are accessible, to a reasonable extent, by both audiences. This way, the interface unites the two audiences, rather than isolating them. This is the "uniformity" referred to in the design process.

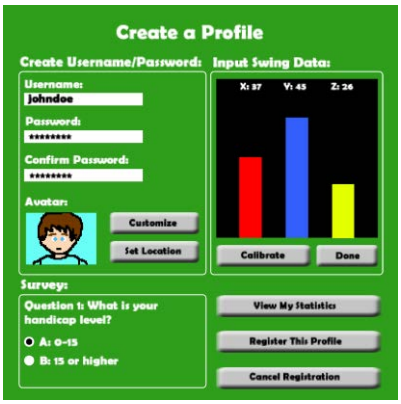

Figure 9: Profile Creation Interface

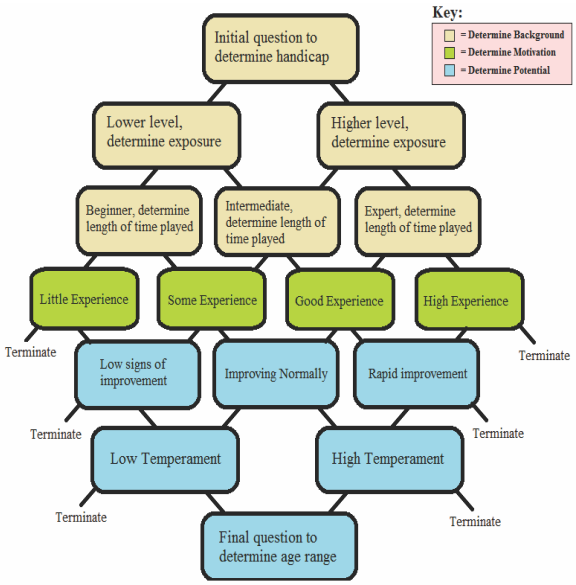

Figure 10: Survey State Diagram

Swing Feedback: Appeal to the Expert Audience

The golf swing assessment component serves the professional golf audience, the niche players. It incorporates aspects of the golf swing knowledge domain into its assessment of a player's skill, allowing these players to track their improvements and gauge their skill level. Casual players use the same interface to input their swing data into their profile, and, should they choose, can use the system's statistics to learn the metrics of a "good" swing.

The interface displays a set of bars, which represent the magnitude of movement of the golf club on the x, y, and z-axis, along with the numeric values themselves. The bars are used as a form of visual feedback, which is simplistic enough for casual players to determine how powerful and how steady their swing was, while at the same time providing the raw numeric values for use by experts to determine where improvement should be made in their swing. The goal of this design strategy is to satisfy the requirements in step 2 of the design process.

During recording, values at every frame on the accelerometer are displayed on the user interface. This interface is shown in Figure 9. A mastery score is applied to all five metrics recorded in real-time. Once values for mastery of each metric have been calculated, these values are stored in the profile of the user. The simplified numbers are easier for novice golfers and casual players to interpret. This way, the interface remains uniform for both experienced golfers and casual players, further satisfying the simplicity requirement in step 2.

Background Assessment: Attend to the Casual Audience

Having added the elements necessary for niche audiences to train and learn, we now shift focus to the casual audience, and provide a less technical means in the interface by which their skills can be assessed. World of Golf supports this background assessment by implementing a questionnaire during profile registration. The questionnaire asks the user a series of questions, each with two possible answers, as shown in the interface in Figure 9. Once the system has acquired enough information from the answers to these questions determining the background the player, the questionnaire terminates and the results are assessed and stored in the user's profile.

The questions are arranged in a tree structure shown in Figure 10. The questionnaire begins at the top of the tree with a general question to determine golf-handicap level, and based on the response, traverses the tree down the left or right branch to ask more specific questions relevant to that user's golf skill level. This pattern of questioning continues until the system reaches a leaf node in the tree, at which point it terminates. This strategy allows the survey to focus on questions relevant to the player, and thus encompasses both casual and expert players. For example, a casual player may be asked about how often he or she visits the driving range for recreation, whereas an expert would instead be asked in how many golf tournaments he or she has participated. While this feature is not necessary for a SRSG to be considered "complete", it does provide the benefit of connecting the casual and expert audiences through matches in characteristics (e.g., an expert and a casual player swings' may be far different, but they may both have the same temperament).

Step 3: Social Hooks and Attractive Features

A completed simulation fulfills the serious game requirement, and the uniform interface opens a game to

both audiences. The remaining task is to fulfill the requirement of a socially relevant game. Since at this point, we have already developed a complete game the goal is to expand the game with social hooks and features to facilitate player interaction. In order to fulfill this third and final step of the SRSG design process, World of Golf includes a "golf world" module. This module, shown in Figure 11, was incorporated into the design to allow players to receive visual feedback on their performance and skill level.

When a player chooses to run a simulation, they log into their profile, and their values for each metric are used to compose a virtual golf player, an artificial agent whose play style and swing depend directly upon these retrieved values. Each metric affects a part of the agent's swing. For example, if a player's profile indicates that the player swings with heavy club speed, the power of the agent's club swing is increased to reflect this characteristic. Outside nuisance factors such as wind and terrain type are implemented as values, which affect the ball's trajectory after the swing is made.

Once a player's profile data is uploaded to a central server, that player's avatar now exists in a networked virtual environment [13]. The player can then search for opponents in the local area or have the system select a location at random. Once an opponent is found, the two players watch a match between their avatars on a satellite image of a real golf course, retrieved from Google Maps, as shown in Figure 11. During a match, players have the option to control factors such as the direction they face, the club they use for each shot, and the power of their swing, although they can relinquish all of these controls to artificial intelligence, causing the avatar to move and play automatically without player input. The golf swing itself is automated in both of these modes and the success of the swing is based on a player's profiled skill levels. By observing their agent's interactions the players become spectators of their own performances. Recent research on transformed social interaction indicates that one's likeness in form of an avatar can have powerful and beneficial impacts on one's real-world behaviors and attitude [26]. Players can see in a concrete manner where they need to improve the physical and mental aspects of their game.

Figure 11: Golf World Simulation (image courtesy: The Links at Lighthouse Sound in Assawoman Bay)

This module serves as the social hook, which connects players, both casual and expert, to other players through their avatars in the game world, creating interactions typical in social network games [11]. The golf-handicap system is the ingredient, which allows for this interconnection. When a casual player is matched against an expert player, the system automatically adjusts the performance requirements to keep the gameplay balanced, allowing a fair match. This connection between the audiences completes the final step of the design process, making the game more enjoyable.

EVALUATION

To demonstrate that World of Golf satisfies the requirements of the SRSG design process, we evaluate it both as a simulation and as a social game.

Simulation Evaluation

In order to determine the validity of the real-time assessment performed by the software, the system was evaluated by comparing profile assessments of golf students against those of non-golf students. The goal of the evaluation was to ensure that the assessment rating scored by a golf player is consistently higher than the rating scored by a player who is a beginner or who does not play golf. This would validate the simulation aspect of the game, making it relevant to the interests of golfers who wish to improve their skills.

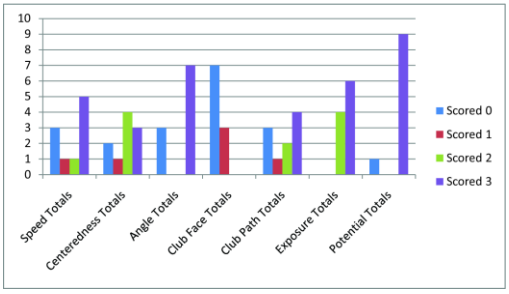

Figure 12: Frequency Distribution of Swing Assessment Scores for PGM Students

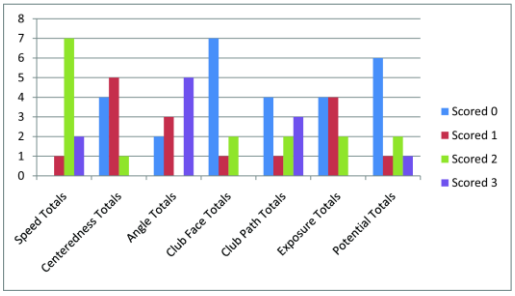

Figure 13: Frequency Distribution of Swing Assessment Scores for non-PGM Students

Averages	Speed	Centeredness	Angle	Club Face	Club Path	Exposure	Potential
PGM	1.8	1.8	2.1	0.3	1.7	2.6	2.7
Non-PGM	2.1	0.7	1.8	0.5	1.4	0.8	0.8

Figure 14: Swing Assessment Averages

The study was performed at a driving range of a PGA Golf Management (PGM) program housed in a university. Ten PGM students and a control group of ten non-PGM students anonymously participated in the evaluation. Each student was instructed to swing the Wii remote until he or she was satisfied with the last swing. Each student also completed the questionnaire along with his or her swing and an anonymous profile.

Students were scored on each of the five metrics (club speed, club face, club path, centeredness at contact, angle of approach) as well as on level of exposure to the sport and level of potential. All students were given the same set of instructions and tested under the same conditions. Since number of attempts varied, only the last swing attempt was given a score. The score represented the overall swing performance for each student.

Golf Skill Results

For the questionnaire module, the responses of PGM students indicated both high levels of exposure and high potential. For the swing metrics, scores of PGM students tended toward extremes, whereas those of non-PGM students varied less. Figure 14 indicates the averages of students tested in each of these metrics for both PGM and non-PGM students. Non-PGM averaged higher in speed, and their club faces were more likely to be open club faces. They scored an average of 2.1 in speed, beating the PGM students by 0.3, and 0.5 in club face, beating the PGM students by 0.2. For centeredness, club angle, and club path, PGM students scored consistently better on average than non-PGM students. In centeredness, PGM students scored 1.8 on average, 0.7 higher than that of the control group. In angle, they averaged 2.1, beating the non-PGM testers by 0.3. In club path they held a 0.3 point advantage as well, scoring 1.7 in comparison to 1.4 for non-PGM.

Social Evaluation

Evaluation of the social aspect of a SRSG is more complex, as the criteria useful for evaluation is, by its nature, multifaceted and less precise; nonetheless, due precisely to these challenges, the benefits of conducting effective evaluation of the social elements are significant. Fortunately some of these challenges have been addressed by the introduction of the SoPlay heuristics [17]. Related work, such as Isbister's [7], demonstrate strategies for important social elements, such as "social learning" and "emotional contagion", the acquisition of basic knowledge concepts and skills which one gains by observing an expert or other individual playing the game, and the chain effect where the emotional responses of one player are passed on to nearby players or spectators who are engaged in the gameplay. These social criteria are important elements of the evaluation of our "social hooks", as they indicate whether the social elements in a SRSG have successfully captivated the casual non-expert audience. Furthermore, they form a generalizable method of evaluation, which developers can use to ensure that by applying the SRSG design framework, they are successfully applying social elements to their games. We use the (SoPlay) heuristics to guide the development of the World of Golf SRSG throughout all stages of our design process, including our evaluation of the prototype, as follows [17].

Accessibility: easier to approach, understand, and play.

This heuristic is central to the success of the SRSG framework as it is aligned with the design goal stated in Step 3 of the framework: addressing the casual audience, or the non-experts. We achieve this in the design stage through the use of the Wiimote interface, which allows casual players to use the system without worrying about complexities such as grips and club types, and the guided in-game questionnaire, which uses less technical questions relevant to the casual player, to form players' profiles.

When asked about how easily they were able to form a profile and watch their avatar play in the Golf World, both the PGM students and, more importantly, the non-PGM students responded in strong support of our design. This indicated that our SRSG development strategies successfully achieved the accessibility heuristic.

Interruptability: Taking advantage of social network use.

We emphasize this heuristic as a key part of the SRSG design goal of facilitating multi-player interaction. In the general case, this involves utilizing social hooks which require little dedication from the player to enjoy the game; that is, a player should be able to pick up and play the game in short, sporadic periods and enjoy the experience. World of Golf's design allows a user to quickly and spontaneously jump into matches in the Golf World and to spectate these matches for as long as the player chooses; commitment to finishing a match is not required, as the avatars can be controlled by Artificial Intelligence using player profiles. This design strategy proved useful in our evaluation, as player feedback indicated enjoyment, even when only playing short parts of matches against competitors' avatars. This further validates the SRSG prototype and design strategies for advancing social gaming [7].

Continuity: Providing asynchronous and permanent worlds.

This heuristic is achieved through applying the "virtual world" social hook. The game world serves to connect players together on a global scale, making a SRSG a container for its own social networks. By including this element, one creates a graphical representation of the "social layer" referred to in Step 3, which leverages "serious layer" simulation for the core game-play and allows the casual player to interact and network with other players, both expert and non-expert. The Golf World module is the game world that achieves this continuity. Player profiles are stored upon creation and their avatars remain permanent entities in the game world. This feature allowed our testers to create profiles and join the virtual community of the Golf World. As more users continue to create their profiles and avatars, this virtual world continues to grow and expand.

Discovery: Creating interest with discoverable content.
This heuristic enhances the replayability of social games, as it gives casual players motivation to discover new ways of improvement and entertainment. In the SRSG design framework, this is applied in Step 2, at the simulation level. In the simulation, SRSG focuses on informative, yet simple presentation of information, allowing casual and non-casual players the freedom to employ multiple strategies and discover new ways of improving. World of Golf allows players to try their own unique swings, similar to real golfers, and the resulting swing data helps them discover where they can improve their golf swing. Feedback from our evaluation indicated that most PGM and non-PGM students discovered new information about their golf swing, including weaknesses of which they weren't previously aware. Through player feedback we succeeded in applying this heuristic in our design.

Virality: Promoting various means for viral growth.
Virality represents the need of a social game to spread and attain a large user base to truly be successful. For this to occur, a social game relies on the user base itself to spread awareness of the game and its popularity. In order for this to occur, consistency of the interface, as mentioned in Step 2, and facilitation of multi-player gameplay, as mentioned in Step 3, are both necessary. The former serves to allow expert players to promote the game to their friends and family, who may not be experts in the subject matter themselves, and the latter allows friends and family, and even strangers, to share the gameplay experience. Together, these allow a SRSG's community to expand itself. World of Golf includes both features in its design, and feedback from our evaluation indicated that most players, both PGM and non-PGM, would share the game with family and friends.

Narrativity: Using vivid in-game and off-game narratives.
Within the SRSG design framework, this involves addressing the needs of the casual audience, from Step 3. Players who are non-experts need to know what events occur and the details should capture their interest. World of Golf will congratulate a player for scoring a hole-in-one during a match, and text-based commentary during avatar matches provides this narrative. This component was received well by both audiences in our evaluation, proving it a useful heuristic in attracting interest and engaging social interaction in a SRSG.

Expression: Supporting self-discovery and customization.
Expression plays into the third step of the SRSG design process, through the in-game avatar. Unique representation of a player in the virtual world allows this environment to reflect real-world social structure. World of Golf follows this design philosophy by allowing players to design their own avatars in the Golf World. This feature was received favorably by both casual and expert testers during the evaluation. Students enjoyed being able to create and customize their own avatars for their in-game profiles.

Reciprocity: sharing in-game resources.
These resources can take multiple forms, depending on the type of game being developed. In World of Golf, the resources available to all players are skill level and characteristics such as temperament and play style. To allow the exchange of these resources, we attach skill and characteristic information to each avatar in the game world, allowing players to connect to friends and opponents with similar attributes. This feature was met with strong approval by both, PGM and non-PGM students and further validates the SRSG design strategy as an effective method for creating a social game.

Sociability: Using social networks as a game mechanic.
The SRSG design process accounts for this heuristic in Step 3, as it is the critical idea behind the formation of the "social layer". Features such as player grouping, allowing contacts and in-game friend requests, and a player search feature all accommodate this idea. World of Golf allows players to search for opponents in the game world, and to form a list of friends with whom they enjoyed playing the game. In addition, profiles can be sorted by characteristics and play style. Our evaluation split the testers into groups for this purpose. Casual and expert players alike commented that they would enjoy using the game as a tool to connect with their friends and to find new ones.

Competition: Promoting playful social competition.
This final heuristic is addressed in the final step of our design process. Facilitating multiplayer social interaction is accomplished by providing the means for friendly competition. This heuristic is also important in determining whether or not a subject matter is appropriate for the SRSG design process. In our case, golf provided a means to encourage competition. Multi-player avatar matches enable World of Golf to provide a means of friendly competition for both casual and expert audiences. Players strongly supported the multi-player aspect of the game and it motivated them to improve their skills in future runs of the simulation. Using these heuristics as guidelines, developers can successfully expand their simulations to meet the design goals of the SRSG framework. They further serve to validate the generalizability of our framework, as they outline many of its capabilities and limitations.

Discussion
The advantage in speed and openness of club face in non-PGM students can be accounted for by the observation that these students, most likely as a result of inexperience, focused on swinging the club with as much force as possible, giving much less consideration to the accuracy of their swing or the steadiness at the point of impact. The reasoning might be that these students interpreted a "good" golf swing as one with the greatest speed at impact with the ball. Their grips on the Wii remote were less steady, causing the wrists to rotate significantly at impact and the club face to switch often to an open position.

While PGM students scored lower in speed and club face metrics, their swings were far more steady and precise. Based on similar reasoning, the PGM students would focus less on putting force in their shot and tended to focus more on maintaining proper shoulder, wrist and body positioning during the swing. This scored them almost an entire point higher on average in centeredness and gave them approach angles and club path scores, which indicated a more experienced golf swing. Based on the scores output by the software, PGM students performed better overall and indicated far higher levels of experience and potential, which supports the validity of World of Golf as a simulation. Like any other, the SRSG design process includes limitations, primarily on the subject domains to which it can be applied. Specifically, the process is restricted to subject domains for which casual audiences can exist without sacrificing the learning elements of the domain. In other words, social interaction must already exist to some extent in the activity being simulated for it to appeal to a less knowledgeable audience. For example, it would be difficult to apply this design process in the creation of a solitaire simulation, since the game of solitaire is intended to be played by a single individual.

While the SRSG design framework is generalizable to an extent, it cannot be applied in every case. Harteveld and Bekebrede's work, which observes the differences in design approaches to learning in single and multi-player games, points out various limitations in our framework [6]. The subject matter present in the simulation, for instance, must itself be socially relevant for expansion of the simulation, using social hooks, to be possible.

Golf, the subject matter upon which our prototype is based, is very much a social experience, since players can compete against one another for better scores and can reflect on one another's performance before, during, and after play. It is also appropriate as a subject for simulation, as it is also a professional sport containing clear and measurable metrics of performance and advancement, metrics which we use in our own simulation. Other sports, including team-based sports like soccer or basketball, and recreational sports such as hunting and fishing, provide environments and rule sets that can be adopted easily into both simulations and social games, and are thus appropriate for development under the SRSG design process. However, subject matter, which is comprised heavily of formal rules and emphasizes single-player play, such as most flight simulation, would lack the social element necessary for the SRSG approach and leaves little to no room for social expansion. Subject matter which focuses on social play, with either very little formal rules or no clear-cut metrics for assessment, such as a Massively Multiplayer Online Role-Playing Game (MMORPG) or a luck-based casino game, is also inappropriate for the SRSG design framework as it would be difficult to transform into a simulation as it does not conform to key principles outlined in Step 1 of the process.

A second limitation placed on the framework lies in its application to the expansion or redesign of completed games. The SRSG design framework cannot be applied to expand a social game or a simulation into an SRSG unless that game already contains the elements necessary to be expanded upon. This is a crucial point to consider for developers who wish to apply the SRSG design framework to games they have already completed. For a social game, this means that the game must already hold the capability of becoming a simulation; it must contain an environment, which reflects real-world scenarios and provide accurate and precise measurements of learning and advancement within these scenarios. If it is exceedingly difficult to extract metrics from the subject matter, which can combine to form these measurements, applying Step 1 of the SRSG process may involve redesigning the game from scratch.

For a simulation, the real-world scenarios being simulated should allow for social interaction, friendly competition, and casual play. The subject of the simulation should not be so technically-oriented and skill-dependent that a non-expert would have difficulty picking up the material. This is evident in the learning curve for a given simulation. Higher learning curves make the game less accessible to the non-expert, and in consequence, less expandable toward the casual audience. Developers should determine, based on the learning curve for their simulations, whether the transition to an SRSG would be a favorable decision.

As Harteveld and Bekebrede point out, the approaches to design of single player and multi player experiences can vary dramatically. Thus, SRSG relies on a balance between the two, and developers should keep this in mind when determining whether or not it is a suitable approach to adopt in their development process [6].

CONCLUSION

World of Golf demonstrates that through a three-step design framework for SRSG development, it is possible to satisfy the interests of both experts and casual players, and do so without isolating the gameplay experience of the two groups. This design study applies the SRSG design process to a physical simulation involving motion detection and synthesis; however the design process could be applied to any simulation whose subject matter involves some form of social interaction, using the criteria and requirements described. To unify the audiences of two very different gaming worlds, the design process is applied in a detailed manner throughout the development process. All aspects of the infrastructure are designed with this end goal in mind. The design method takes advantage of the role of social networks in today's world to achieve this goal, introducing new possibilities for simulation game design. In addition to providing a strategy for the development of new, socially aware simulations, the proposed design model encourages the expansion of pre-existing simulation games without modification of the core elements, allowing them to engage larger audiences.

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