Off the Beaten Track! The Infinite Scotland Serious Game Design Approach

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Abstract. In this article, we discuss the development of the Infinite Scotland Facebook serious game. The Infinite Scotland serious game was supported by the Scottish National Heritage, Creative Scotland and Creative Services Scotland in order to promote the links between biological and cultural diversity in Scotland. To engage a younger demographic, Infinite Scotland developed a knowledge-based, puzzle-centric serious game for a social media platform (Facebook); projecting the links between biodiversity and cultural diversity via player exploration and competitive gameplay. In this article, we describe our motivations for conducting the work, discuss the game design in detail, and finally speak about the implementation and development of Infinite Scotland.

Keywords: Serious Game, Cultural Heritage, Infinite Scotland, Reinforcement Learning, Social Media.

1 Overview (Motivation)

Scotland is a rich and varied country, which benefits greatly from tourism and its associated economic activities. The Infinite Scotland (IS) serious game described in this article is a collaboration between the Scottish National Heritage [1], Creative Scotland [2], Creative Services Scotland [3] and the Digital StoryLab [4] at Heriot-Watt University in Scotland. Serious game development has come a very long way in recent years and as such, is diverse and varies in its approach. Serious games can be designed to implicitly and indirectly allow players to assist in solving complex problems or aid in the learning and retention of specific knowledge; evaluating the analytical and logistical outcomes of player's playthrough cases for success.

IS is the latter: a Facebook-orientated serious game aiming to highlight the biological and cultural diversity of Scotland. The IS serious game aimed to attract an adolescent and young adult demographic to the *"Infinite Scotland"* material. IS is a knowledge-based, puzzle-centric, interactive serious game which allows players to both develop and enhance their knowledge of Scotland; in particular it aims to highlight the biological and cultural diversity that represents a modern, yet historic Scotland.

The design methodology, specifically the design pattern, was originally developed to first **introduce** players to the six ecosystem types of Scotland, then

deepen their knowledge of these unique and diverse aspects, and finally **reinforce** this knowledge through competitive gameplay via Facebook. By completing a jigsaw puzzle via player exploration around Scottish sites, the player develops the links between biodiversity and cultural diversity through active engagement; resulting in a greatly more enjoyable retention method over that of a more passive presentation model.

IS was developed so that it could be deployed via social media, specifically Facebook, and additionally via Scottish Schools, in order to make it accessible to a wider demographic. The IS serious game content used the Infinite Scotland multi-media materials already assembled, of which were collected by Creative Services Scotland. IS's game design and production was completed on a £5k budget funded by Interface (Scottish Funding Council). In this article, we first focus our attention on the motivations and game design (section 2), followed by discussing the technical development and the implementation from a system's architecture perspective (section 3), before briefly addressing the current state of the IS serious game and projected future work (section 4).

2   Game Design (Theory)

2.1   The Serious Game Remit

IS is an exploration of Scotland's DNA - one strand is its biodiversity, the living and inert elements it is made of: rocks, insects, animals, plants, soil and fish - the other strand is the culture of the human beings that live in it: the way they celebrate, express themselves, live, play and describe their environment. [10] At its core, IS implores this fundamental exploratory approach to learning, gifting the player the ability to determine what information they would like first to digest.

Yet the process of breaking down an entire country into concise and coherent segments of information was no small task. When an ecologist has this problem they take a sample at random by throwing a quadrat - a small wooden square - and count the number of species in its boundaries. IS is built upon such an approach, although the metaphorical quadrat will be constructed of the most well known six ecosystem types rather than a few metres. The six ecosystem types are: *"Badenoch and Beyond"*, *"Trossachs and Stirling"*, *"Small Isles"*, *"Orkney"*, *"Edinburgh and the Lothians"*, *"Dumfries and Inner Solway."* (Fig 1). Via this method the player is aided in clustering the learning material into appropriate sub-locations that compose Scotland, allowing them to identify where information is specific to, yet still leaves the scope of the information vast.

The purpose of IS lies in how the two DNA strands are connected and it would suggest that the true personality of Scotland is better appreciated by both. Yet, IS is only an introduction and not an encyclopedia or a definitive guide to Scotland's flora, fauna and culture. It aims to provide a comprehensive taster of some of the most distinctive aspects of each, and that it whets your appetite to find out more, and perhaps to add your own thoughts, images and knowledge. In order to further assist the player in taking in this data, information
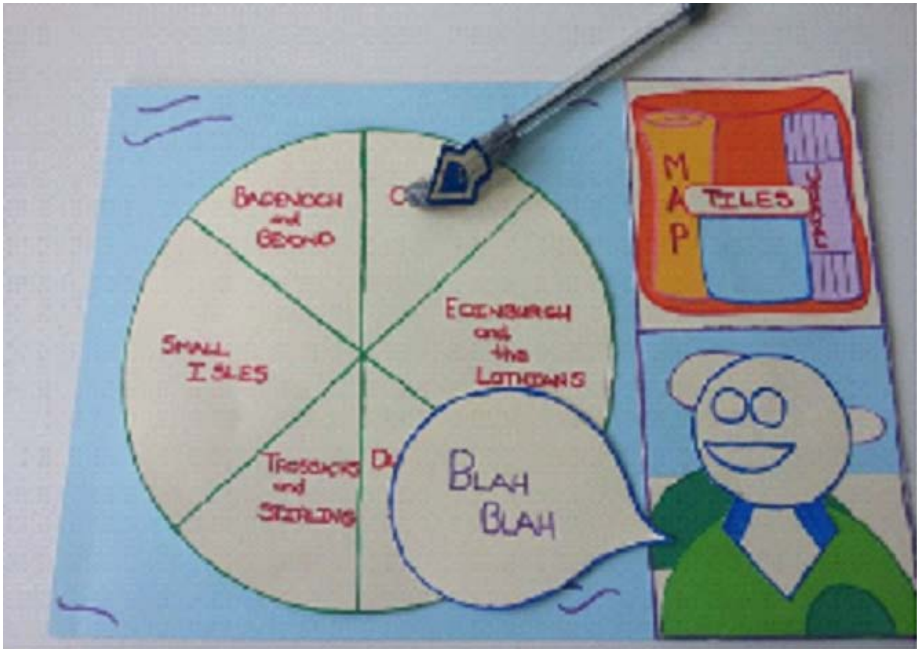
Fig. 1. Early paper prototype demonstrating the basic interface design

is subsequently further broken down and placed into one of four classification types so that relationships can be formed between entities.

The four classifications are: *"Wildlife, Environment, Culture and Connections."* Firstly, wildlife represents the biodiversity of Scotland with respect to the 90,000 species that inhabit it. Secondly, environment consists of the mosaic of habitats and scenery that make up the complex and varied landscape. Thirdly, culture is composed of folklore, myth, religion and custom, including the two indigenous languages. Lastly, connections describes the quirky, the little known, the weird and strange of Scotland. With information now specific to particular classifications, in conjunction with locational attributions, players now have the ability to absorb a vast array of information in a logical manner. The introduction of knowledge has now been completed.

2.2   The Infinite Scotland Gameplay

With both the goal and scope of information laid out, the process in which a player gains access to this information is key. The gateway to this introductory, yet now meta-constructed, surplus of information is represented graphically through the use of an ecosystem-orientated, top-down map of Scotland (Fig 2). Yet the player's ability, and innate desire, to freely explore at will may lead to a dysfunctional and highly unproductive learning session; in turn leading to

Fig. 2. Final top-down map illustrating the six ecosystems and navigational guide component

confusion or frustration at a lack of progress, or overwhelming absorption of information.

Thus a navigational guide has been implemented to assist the player by providing preliminary instructions with the aim of developing the user experience in a structured manner, providing an indirect, implicit goal to data gathering. This is achieved through the use of a highly primitive, intuitively implicit narrative structure that frames the information as a series of checkpoints in a backpacking trip around Scotland. Through player exploration of Scotland, a player has the ability to visit any of the six ecosystem types on their visit, upon which the map will then zoom in to show the ecosystem type in full with all of the available classification data entries. It must be noted that classification entries are constant, and not random, to their specific ecosystem types in order for the player to attribute knowledge at a classification level to an ecosystem type level - of which will be used for player reference and later reinforcement.

Yet in order to provide this catalog of information in a manner not similar to the direct, overextended data-push, there exists an additional goal, discussed later, which requires not only learning the information, but applying it in a competitive manner. As suggested by our design pattern, both learning depth and reinforcement must be exercised. Thus the information for any classification
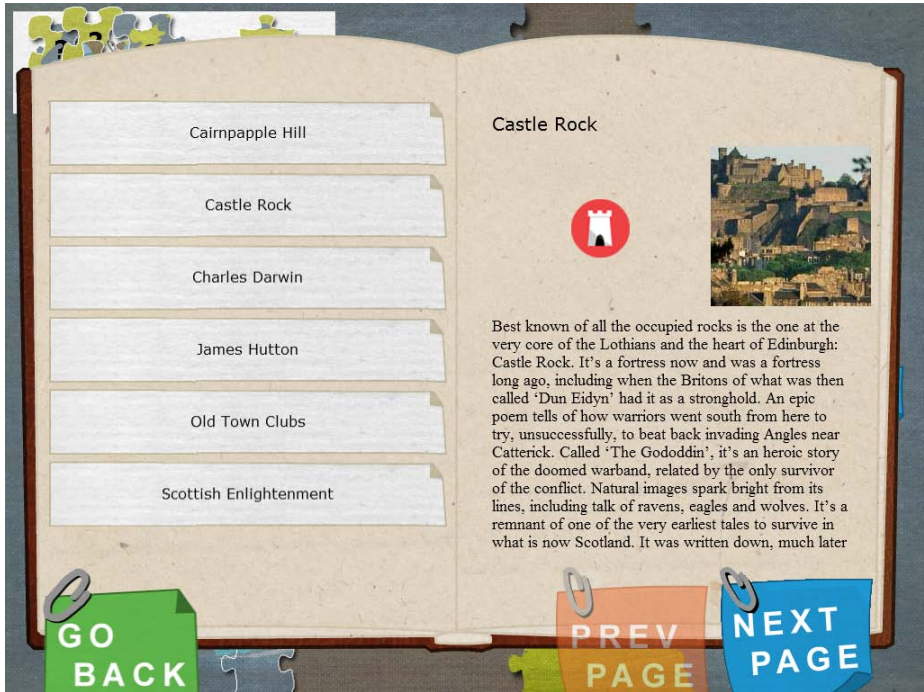
Fig. 3. The IS game diary detailing an ecosystem's classification entry

within any ecosystem type will be presented as only a brief overview of the information itself. The full text, along with complementary assets, appears within the complementary, comprehensive diary (Fig 3). The diary was developed for a number of reasons: to encase the full text of any classification for further information, enable the player to readdress relevant information for competitive advantage, and to allow the player to gauge their progress on their trip in full. Through the use of this mechanic, it aims to allow the player to get the gist of the essential information at a glance, whilst providing the player access to additional information that can develop further but at the player's own pace; disregarding the requirement for the player to read all of the information in one sitting and risk becoming disillusioned or agitated. The deepening of knowledge has now been completed.

Yet the introduction and deepening of information on its own is not serious game compliant if there exists no way in which to reinforce, thus test, the player's knowledge gained. Subsequently a direct, yet optional, goal for the player to undertake whilst obtaining information is to complete an interactive puzzle, specifically one in the form of a jigsaw (Fig 4). The reinforcement mechanic employed is a reactive one, working in parallel with the learning mechanic, as the player is required to make use of the data gathering in order to partake in

Fig. 4. The IS jigsaw game mechanic illustrating a mid-journey breakdown

the jigsaw, yet this remains optional and can be undertaken at the players's own pace and discretion.

The jigsaw is composed of three parts: the first is collecting pieces, the second is fitting pieces into the jigsaw outline, of which when completed, is a map of Scotland, and the third is of a competitive nature. Although a number of additional parameters are used, the premise is that random jigsaw pieces are awarded by visiting classification entities. Each awarded jigsaw piece is the same standard shape yet is composed of a unique overlay image, representing the map in some way.

The base mechanic implores the player to use the visual cue to attempt to place the jigsaw piece into the correct position, yet such a primitive approach does not attempt to reinforce the player to make use of information relevant to what they had learned about Scotland, in particular the data within its ecosystem and classification types. Thus, each jigsaw piece has an additional clue in the form of a random snippet of information, presented in a similar manner to the classification data entries, which allow the player to recalibrate a jigsaw piece's hypothetical location based on an ecosystem type rather than purely on visual, making the jigsaw both sensory and logistical in form.

The enhanced mechanic would now implore that if the player knows the location of a jigsaw piece's information, then the player now has a hypothetical

one in six better chance of being correct. Yet it must be noted the provided information is random and thus a player may or may not have visited that classification site as of yet, thus not having the knowledge to make use of it. The overall challenge for the player lies in recognizing and making use of information to assist in placing a jigsaw piece relevant to both its image and location in order to complete the jigsaw. The reinforcement of knowledge has now been completed.

2.3   The Game Design Construction

Once a serious game has laid out its proposal, decided its approach in terms of learning outcomes, and justified the implementation of its design pattern, the application of game design theory is now needed in order to develop the application further. The IS serious game has so far employed two base mechanics in order to achieve its desired design pattern: learning and reinforcement. The latter of which is more relevant to game theory as it includes the use of a traditional game mechanic; in the form of the jigsaw puzzle. A strict balance must be adhered to in order for a player to enjoy the serious game whilst at the same time providing some degree of feedback, in this case, the continued interest level of a player. In order to accomplish this goal, a number of additional mechanics were employed with relation to the main jigsaw mechanic.

But with a quick consideration for the meta-design methodology, there always existed the desired prospect of IS appealing to a variety of user play styles or 'player types'; such that IS would be both presentable and enjoyable to the target, and to a considerable degree, a wider demographic. Thus the high level design decision to incorporate a variety, and not purely a single game mechanic or play element, was stipulated for the jigsaw mechanic. In that IS would deliver both a competitive achievement subsystems whilst addressing social and exploratory prospects. Such a tactic designates the design address theory just as much as an iterative design process to deliver a substantiated play experience for all hypothetical players involved. Yet with the inclusion of a target demographic, certain priorities must be maintained in order to address that target group, and the subsequent prospected play styles, as priority.

The core design consideration for IS was that it would be integrated on Facebook under the concept of a *"one minute game"*. The notion of *"jump-in, jump-out"* gameplay was developed through the use of a move counter feature; such that each classification would spawn a random jigsaw piece of the same classification, of a select color, and award a move for that classification move counter. Specifically this meant that in order to attempt and place a jigsaw piece of color red, the player must first visit the red classification type(s) in order to be awarded the jigsaw piece in the first place, and use the awarded subsequent red moves to attempt it.

Additionally the spawn location of the jigsaw pieces was limited, and employed a tower stack effect such that the player would not be able to unlock everything and then attempt the puzzle - as lower jigsaw pieces would be piled beneath the highest. Lastly, was the mechanic of locational suggestive feedback or the

"hot or cold" effect, where after placing a jigsaw piece on the board it would feedback an appropriate grade based on the distance the player was incorrect. Thus an A+ would mean the piece was correct and would snap into place versus an F which meant the player was nowhere near correct, and all the variance in between.

These control constraints allow the gameplay to remain consistent and coherent over the course of the journey through Scotland. Additional features and mechanics which aim to control the puzzle mechanic in such a way to allow it to remain rewarding over the course of multiple attempts were developed. First were the additions of *"powerups"* which rewarded the player for such things as using the journal to source information, to slotting a jigsaw piece correctly the first attempt. Such instances of power-ups, include free automatic slotting to a higher snap grid for the next placed jigsaw piece. These were pivotal in continually rewarding the player over the course of many visits to IS for completing constructive events. In effect, even though visiting the journal to recap information in order to get a lower move multiplier might come as innate nature, the prospect is that the player learned additional information than was not originally present in order to achieve their goal.

The other mechanic developed to encourage both a higher level of difficulty and substantial solo-play prospects was the *"rotten jigsaw piece"* feature. This in effect meant that if the player left a jigsaw piece on the board too long without moving it, it would start to decay and begin a countdown timer. If the player did not move the jigsaw piece again before the timer reached zero, then the jigsaw piece would be returned to the box and a negative effect would be applied to the board; such as hiding the grade score of all jigsaw pieces on the board to removing an already slotted jigsaw. These additional mechanics were developed through the use of iterative development of design theory and user feedback.

As stated previously, in order to avoid the pitfalls of the traditional data-push approach, IS will incorporate a competitive or oppositional configuration with regards to the jigsaw puzzle mechanic, in particular a *"best"* play or high score system. This approach will be accomplished via a number of global parameters that will be visible to other players via the Facebook completion screen in order to incite competitive tendencies - such as map percentage complete and total moves taken. The highlighted count of the number of moves one player has taken to achieve a particular completion percentage is used as a competitive incentive to keep both the player in question, and any other social users, coming back to play.

The integration of IS within Facebook was deemed pivotal as it would allow both the scope and magnitude of the information to be accessed further via social ties, thus allowing for such competitive aspects to be formatted. Yet due to the nature of competitive play the notion of fairness was addressed with all players getting random pieces irrelevant of their previous knowledge of Scotland. The inclusion of Facebook additionally offered the prospect of Creative Scotland to collect analytical information on such keys items as the most visited ecosystem type to the highest number of views for all journal entries in order to better develop the material and tailor it towards the player in the future.

3   Game Implementation (Application)

3.1   The Architecture

While primarily designed with social media integration in mind, the IS game required both a fully featured online version and an offline version to be run in environments where internet and social media access may be limited (e.g. schools and universities). For this reason we made the design decision to develop and produce IS with Adobe Flash. Whilst a serious game developed in HTML5 and Javascript may have allowed for greater integration through a wider range of web-enabled devices, packaging the game through Adobe Air [5] provided us with a mature technology for deployment to both web and desktop platforms - with the same code base. Furthermore, by building IS atop the open-source Starling Cross Platform Game Engine for Flash [6] we would be able to in the future to extend our deployment to both the Apple and Android App stores with minimal development costs.

The core of the IS game architecture (Fig 5) was built upon the open source Starling Game Engine developed by Gamua [6]. The IS game consists of three main layers: the Game Layer (built with the Starling Game Engine Framework [7]), the Storage Layer (integrating the game with a Flox server back-end [8]), and a Social Media Layer (a JavaScript Layer that implements the social media provider APIs). The Game Layer encapsulates the game logic and controls communication between the layers through generic events (e.g. save game, login, login failure, post status). The Storage Layer allows us to save game locally when no internet access is available and to save the data to the cloud when it becomes available again. The Social Media Layer controls access to the social media functions and handles account access, log in, progress posting, etc. The separation of these layers allows us to maintain a workable version of the game even when web-based features are not available.

3.2   The Game Layer

The Game Layer contains all the game specific logic as well as controlling access to the various embedded assets (sprites, sounds, information and dialogue), input devices (mouse, keyboard, touch screen, etc.), as well as controlling sounds, screen transitions and the Graphical User Interface (GUI). IS was developed as a primarily event driven game and takes advantage of the event management system within AS3 and the Starling Framework to handle messages within the Game Layer. When an event is triggered an event 'bubbles up' the display list hierarchy to the Game Core. The GUI employed a similar layered technique as seen in (Fig 6).

The Game Core then decides to handle the message itself or to pass it back down a branch of the display hierarchy to the correct event handler. For example, when the player correctly places a puzzle piece on the tile screen, a gameplay event will be triggered. This event will then 'bubble up' the flash display list from the tile object to its parent screen and finally to the Game Core. Both

```
+-------------------------------------------------------------------+
|                        Application wrapper                        |
| +---------------------------------------+  +--------------------+ |
| |              Game Layer               |  |   Storage Layer    | |
| | +-------+-------------+-------------+ |  |                    | |
| | |       |   Managers  |  Game Logic | |  |                    | |
| | |       |             |             | |  |   ID Generator     | |
| | |       | Asset loader|   Events    | |  |                    | |
| | |Embedded|    Input   |   Objects   | |  |  Player Progress   | |
| | |resources|   Sound   |   Screens   | |  |                    | |
| | |       | Game screens|    States   | |  |  Usage Statistics  | |
| | |       |  Dialogue   |     GUI     | |  |                    | |
| | +-------+-------------+-------------+ |  +--------------------+ |
| | |            Game Core              | |  |   Game  Servers    | |
| | +-----------------------------------+ |  +--------------------+ |
| +---------------------------------------+                         |
| +---------------------------------------------------------------+ |
| |                         Social Layer                          | |
| | Authentication    Login    Fetch Details    Post Progress     | |
| +---------------------------------------------------------------+ |
| |                     Social Networks APIs                      | |
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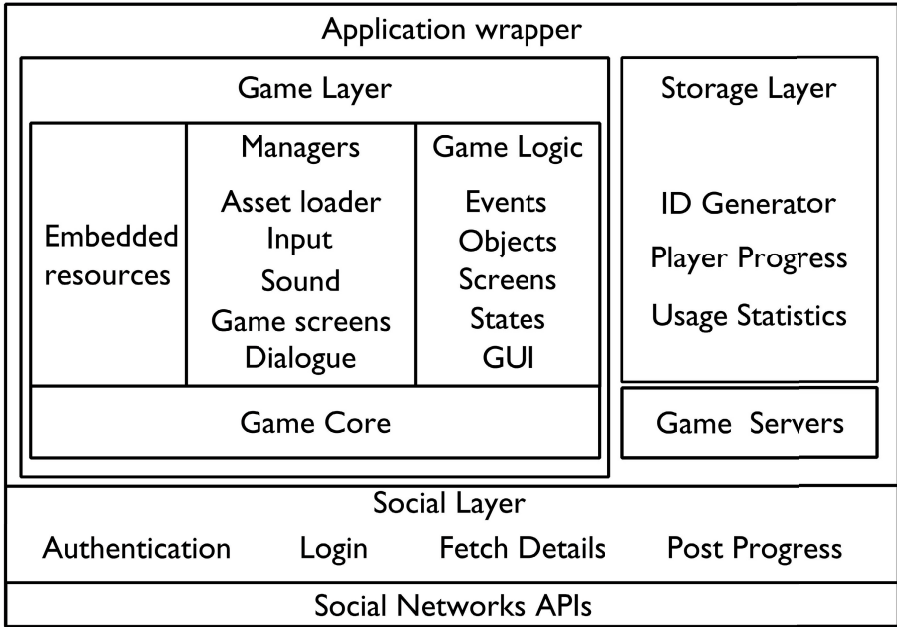
Fig. 5. The IS game architecture detailing the various levels of system design

the Storage Layer and the Social Layer will be subscribed to this particular event. In this case the Storage Layer will update the player's progress and save if appropriate. While the Social Layer will - provided a successful log in attempt has been made - request to post the player's progress to their Facebook wall.

The asset loader stores a list of game assets by name and serves to abstract the location and type of the asset from the core game logic. This allows us to load assets without needing to know whether they are stored locally or are being pulled from the web on application start-up. This allows for a potential extension of the game to include assets pulled from user-generated content on the Infinite Scotland website.

3.3   The Storage Layer

Since the IS game was developed as a social media game, we had to take into consideration the possibility that our players would be accessing the IS game across a number of different devices, platforms and use conditions. We chose the Flox game back-end as it met all our necessary requirements at minimal development cost. Flow allows us to save locally, or to the cloud and access the data from any devices using a unique user ID. This ID is generated by the Storage Layer based on the user's Facebook ID, email address (when Facebook access is denied), or as a random value tied to the current device. While the third option

Fig. 6. The IS GUI broken down

does not allow for users accessing data across multiple devices, it still allows for cloud storage for the current device and provides a unique identification for the storage and analysis of usage statistics.

3.4   The Social Media Layer

For the web version of the game, IS was deployed as a hybrid JavaScript/AS3 application. Social media integration was implemented via JavaScript within the application's HTML wrapper [9]. This allows us to directly utilize the JavaScript API's provided by social media service providers without having to implement third party libraries within the game logic core (Fig 7). This allows us to stay up to date with the latest implementation features through generic calls to this layer triggered from within the Game Layer (e.g. login, log out, post status) without altering our game code itself.

The current implementation of the IS game has been successfully deployed and tested in both its web-based version and offline version in both Windows and Mac environments. The Social Media Layer currently only implements functionality for accessing Facebook accounts. Future work may include expanding the Social Media Layer to cover a wider range of Social Media services (i.e. Twitter) and better integration with Facebook features such as game achievements and friend lists. Fully porting the IS game for deployment to Apple and Android
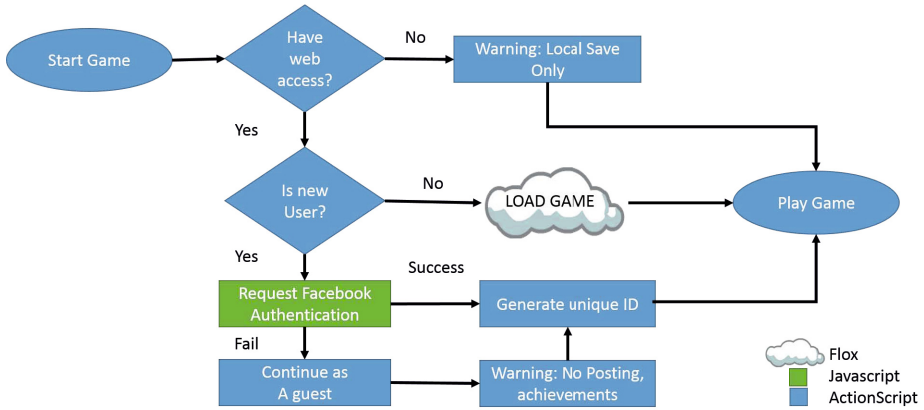
Fig. 7. Facebook JavaScript API [9]

devices would require implementing a Social Media Layer within the Game application. Thus, modifying graphic libraries for a number of different devices and a number of interface enhancements within the Game Layer to ensure readability of interface elements across the wide spectrum of display sizes available in these marketplaces.

Analysis of usage statistics on a wider scale after the IS serious game is fully launched to the public on the Facebook game store. Further potential future work would include integrating the IS serious game with the rest of the Infinite Scotland ecosystem (website and apps). Thus, user generated web/app content could be integrated into the gameplay experience.

4   Proposed Game Evaluation

The evaluation for IS is currently underway, and whilst it cannot be fully detailed here at this time, both the method behind the evaluation method of choice and an overview for the desired outcomes can now be discussed. The purpose of evaluation within a serious game is to justify the design decisions, and specifically for IS, with two parameters in mind: did IS achieve its serious game remit and did IS achieve its user remit?

Specifically for the serious game aspect of IS, Creative Scotland wishes to know a variety of analytical data in order to ascertain on how to proceed with IS in terms of data and future content. Such data could include what ecosystems users enjoyed the most (visited percentage) to what classifications users retained the best (correction percentage). With such preliminary data, Creative Scotland would then have the prospect to include further classification entries with regards to their user group in order to better associate IS to its target demographic. With regards to the IS design pedagogy and methodology, this analytical data could then in turn evaluate whether or not the user learned from the material or not.

More specifically, both if a user was introduced to new material and if they could retain and use it could be evaluated.

The second form of evaluation is more user centric and would follow traditional game design evaluation. It would consider such factors such as if the game is worth playing to the player or as to whether or not it is considered fun. This could in turn adjust the difficulty of the puzzle by looking at the desired time of completion in comparison to actual time of completion. Such evaluation could then adjust the game to make it more susceptible to the target demographic and additionally allow IS to deliver more analytical data back to Creative Scotland.

5   Conclusion

IS is a knowledge-based, puzzle-centric, interactive serious game which allows players to both develop and enhance their knowledge of Scotland; in particular it aims to highlight the biological and cultural diversity that represents a modern, yet historic Scotland. The IS serious game developed a unique design pattern and adjusted game mechanic to address the transfer of knowledge of a highly scoped catalog of Scottish information. It accomplished this feat through structured exploration and the introduction of ecosystem types and classification entities, deepened that knowledge through enhanced journal entries, and enhanced that further through application in a motivational, yet traditional, game mechanic.

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