Building players' engagement – a case study of games with a purpose in science

Paweł Łupkowski, Dagmara Dziedzic
Adam Mickiewicz University, Poznań
pawel.lupkowski@amu.edu.pl | dagmara.dziedzic@amu.edu.pl

Abstract: The aim of this paper is to present and discuss interesting and inspiring game-design techniques employed in selected games with a purpose. We are interested here in a particular domain of these games' application – namely science. We consider how particular techniques (like implementing Free2Play mechanics) might influence players' engagement.

Keywords: games with a purpose (GWAP), players' engagement, citizen science, gamification, game design

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1. Introduction

Games with a purpose (GWAP) are designed to meet two (distant at first sight) aims: a) to provide a player with an enjoyable game, and b) to serve as a tool to solve a certain difficult problem. Since the term coinage and the first successful GWAP implementation by Luis von Ahn (2006), we have been witnessing a growing popularity of game-based approaches to the widely understood problem solving in many different domains. Just to mention games with a purpose used, e.g., for image labelling to improve search engines and accessibility of web pages (e.g., *ESP* game, *Squiggl* – see Ahn, 2006) or gathering common sense data about everyday objects (e.g., *Verbosity* – see Ahn, Dabbish, 2008). However, from our perspective the most interesting and promising field in which GWAP find their applications is science. Many game-like elements and techniques are incorporated in order to generate and analyse data in different scientific procedures. This movement might be connected with the growing popularity of such phenomena as **citizen science** (see e.g. Bowser, Hansen, Preece, 2013 and an overview by Borrell, 2014), **crowdsourcing, human computation** (see Quinn, Benderson, 2011) and **gamification** (see e.g. Deterding et al., 2011). In this paper we will be interested in games that function in the intersection of these four domains, i.e. GWAP used in order to facilitate scientific procedures, sometimes referred to as "scientific discovery games" – hereafter SDG (see Cooper et al., 2010a, 2010b). Our area of interest is presented in Figure 1.

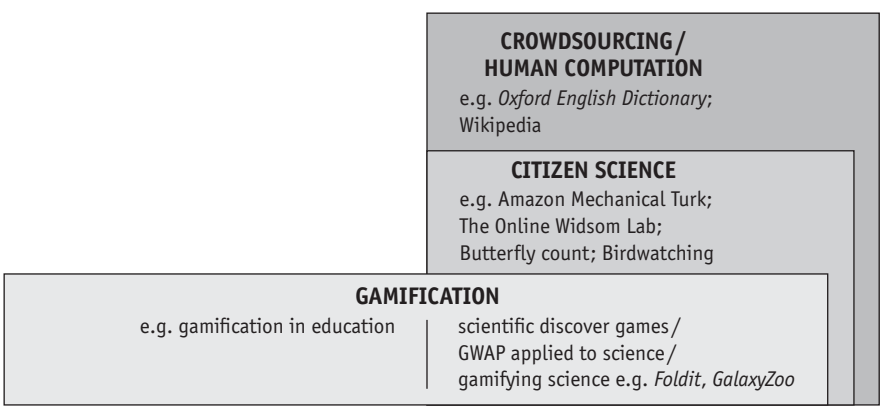

Figure 1. The conceptual map of scientific discovery games

In our opinion SDG constitute a convenient field for research on motivating players. The reason for this is that such games try to match two distant aims mentioned above, i.e. provide excellent fun and useful output of a game (useful in terms of the value of the obtained data).

The aim of this paper is to present certain scientific discovery games which – in our opinion – may serve as a source of inspiration for designing games of this kind. Games chosen for this paper implement interesting techniques and solutions which are aimed at strengthening player's engagement and thus obtaining better output results. The main intuition behind our study is that it is not enough just to make a player aware that the game has some useful purpose (however, it is very important). To design a playable and useful game to use it in the scientific process one should take care also about the engagement and the fun part of the design.[1]

The paper is structured as follows. In the first section we present a scientific discovery games that constitute an excellent example of a game design where the real data are used. The second section discusses the case in which a simple mechanics is used to explore really complex biological ideas. The next section presents how models can be employed in order to improve game design. The fourth section is devoted to the issue of bringing and incorporating the inspiring techniques and methods from other game genres (in this case Free2Play games) into SDG. We conclude with a summary and discussion covering the presented games.

2. Give your player the feel of real data

When you think about designing the SDG (and, in fact, also of other types of games) one should certainly aim at increasing the excitement and engagement of players. In the case of SDG one of the ways to achieve this comes almost out of the box. The reason for this is that in almost all cases the point of departure is a scientific problem accompanied with

[1] This issue is discussed in the broader context of digital games e.g. by Sweetser and Wyeth (2005) and by Cowley et al. (2008) exploiting the concept of **flow** (see Csikszentmihalyi, Csikszentmihalyi, 1992); and also in the narrower scope of serious games e.g. by Mitgutsch and Alvarado (2012).

real scientific data. When one tries to determine who will be the target of such a specific type of game as SDG, one must say that it will be with high probability someone who is interested in science (often someone who is already acquainted with the idea of citizen science). Consequently, the simple idea would be to provide the players with the thrill of dealing with and analysing the real data.

As the somewhat prototypical example we can point at the *Galaxy Zoo* (GalaxyZoo.org, 2007; see Masters et al., 2010). Its users classify pictures of galaxies obtained from *Sloan Digital Sky Survey* (SDSS). Each galaxy is classified as belonging to one of the categories that are clearly recognizable in the game interface. The game itself is very simple and is not very playful. It gives a feel of an esthetic and well designed tool for performing classification – see Figure 2. However, what is important is the main motivator used here, which is worded nicely in the game's slogan: "Few have witnessed what you're about to see" – most of the pictures presented in *Galaxy Zoo* have not been seen by anybody before. You will give your time for this project and as a reward you will see unique and authentic photographs of space.

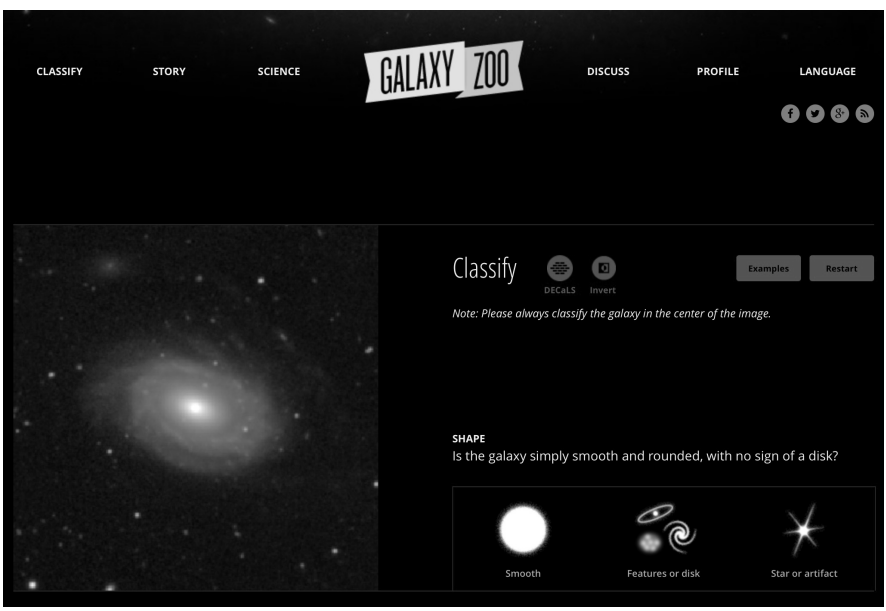

Figure 2. *Galaxy Zoo*. Notice how intuitive the interface is and how attractive the photo presented to the player is (GalaxyZoo.org, 2007)

Galaxy Zoo is a game which is well recognized and discussed (see e.g. Masters et al., 2010; Łupkowski, 2011; Kleka, Łupkowski, 2014). That is why we would like to point out yet another game with similar solutions which is worth attention. *Galaxy Zoo* is now a part of the Zooniverse service (Zooniverse.org, 2007) hosting nearly 40 projects at the moment (for example, we can classify pictures of the Moon surface in *MoonZoo*, classify objects on pictures of the sea floor in *SeaFloor Explorer*, there even is a project about uncovering the history of citizen science – *Science Gossip*). Here we will be interested in the game *Operation War Diary* (OperationWarDiary.org, 2014a) hosted at the *Zooniverse*. The game shares the central idea with *Galaxy Zoo*, namely it provides a player with the unique possibility of interacting with the real data – in this case: original British Army First World War diaries. It is highlighted in the introduction to the game tutorial. The player reads: "Become a Citizen Historian and help Imperial War Museums and The National Archives reveal the story of the British Army on the Western Front during the First World War" (OperationWarDiary.org, 2014b).

The objective of a player in *Operation War Diary* is to classify events written in war diaries of an actual unit. You browse a diary and mark entries using pre-established tags (e.g. place, army life, unit activity, time, date, person, casualties). As for the interface, it is similar to the one used in *Galaxy Zoo* and it is very intuitive (see Figure 3). Before actual play, you go through the tutorial explaining game objectives and the process of coding. After that, you can choose one of 38 documents available for coding (see OperationWarDiary.org, 2014c). In order to tag the documents one does not need any specific knowledge, however, it is worth noticing that there also is a knowledge base about army regulations and type of documents use which is available in the "Field Guide" section. To understand and learn the broader context you can read the game blog which presents entries about history of WWI. If you want to share your thoughts and ask for some advice you can use the chat in the "Talk" section.

At first sight *Operation War Diary* seems a little bit monotonous and dull (like *Galaxy Zoo* might be) – the user just has to browse the documents, spot certain fragments and tag them. During the play it becomes clear that dealing with actual documents, written by people taking part in historical events is extremely thrilling. The game itself does not offer

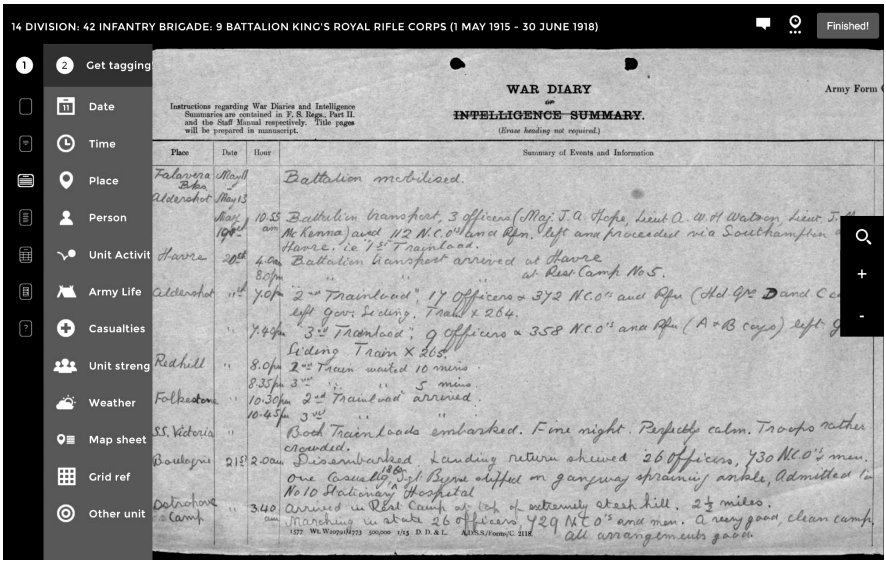

Figure 3. Operation War Diary. The scan of the actual historical document is presented to the player. The interface is intuitive and the used icons help to browse tag categories (OperationWarDiary.org, 2014b)

multimodal experiences. It does not contain any additional materials (such as movies, animations, interactive elements). In our, and as we can guess the game designers' as well, opinion they are not needed, because you know that the described events really happened. The real history is enough to excite and engage the player who is interested in the WWI (just like the astonishing pictures of galaxies in *Galaxy Zoo*). This is reflected by the number of tagged pages. Within one week from the Operation War Diary release 104,167 pages were classified what constitutes 85 completed diaries (Smith, 2014).

When it comes to embedding multimodal experiences into a game about history we think that a game from another genre is worth mentioning. It is the *Cechoslovensko38–89* game (Cs3889.cz, 2015). It is a so-called *serious game* (see Connolly et al., 2012) – so it is not in the main scope of this paper. However, it provides many examples of inspiring game-design choices, which might be used in GWAP of the kind we discuss here. The game is a complex simulation presenting the key events in the history of Czechoslovakia. The target of the game are high school students. The game allows them to study the historical events from many perspectives.

Cechoslovensko38–89 contains multimedia materials covering testimonies of witnesses of historical events, archival materials and animations presenting the game plot. One of the problems that had to be solved in this project was to clearly distinguish the historical material from the game plot, namely elements added in order to construct the game. The chosen solution was to stylize the game elements in the comics manner (Šisler, 2015). What is also stressed by the game designers is that the game itself is free from interpretation of historical facts and presents many views on key historical events.

The examples presented in this section share one common feature – the materials used in them are of a visual character. Consequently, a question arises, what can you do when your data is not visual. It seems that the strategy is to point out and explain their importance. As an example of such a project we may mention *Wordrobe* (Wordrobe.org, 2012; see Venhuizen, Basile, Evong, Bos, 2013). It is a set of games developed to enable semantic annotation of the natural language data from the Groningen Meaning Bank (GMB, 2012). All tasks in the games are obtained from GMB and the annotated texts are used to improve the corpus which is stressed in the project introduction.

3. Use simple mechanics for complex ideas

One of the central concepts of GWAP is to use specific human abilities, that are available for us, but still are really hard to imitate for machines. One of such abilities is that we have strong puzzle-solving intuitions. We like to play visual puzzles and we use mental rotation of 3D blocks and 3D structures without a serious effort. The game that exploits this ability is *Foldit* (Fold.it, 2008a). It is a very inspiring example of a design which uses simple game-mechanics for solving an extremely complex problem. As we may read on *Foldit* website: "Foldit attempts to predict the structure of a protein by taking advantage of humans' puzzle-solving intuitions and having people play competitively to fold the best proteins" (Fold.it, 2008b).

The underlying problem of this game is to establish possible proteins' structures. The number of possible combinations in which a single

protein can fold in is enormous. Dealing with this problem with traditional approaches (expert knowledge, automatic methods) is costly and time consuming. *Foldit* allows for attacking this problem by means of a game which does not require any specific biological knowledge, but only transforming certain 3D structures according to the simple rules given. Consequently, *Foldit* gives its players the feeling of a simple puzzle game – see Figure 4.

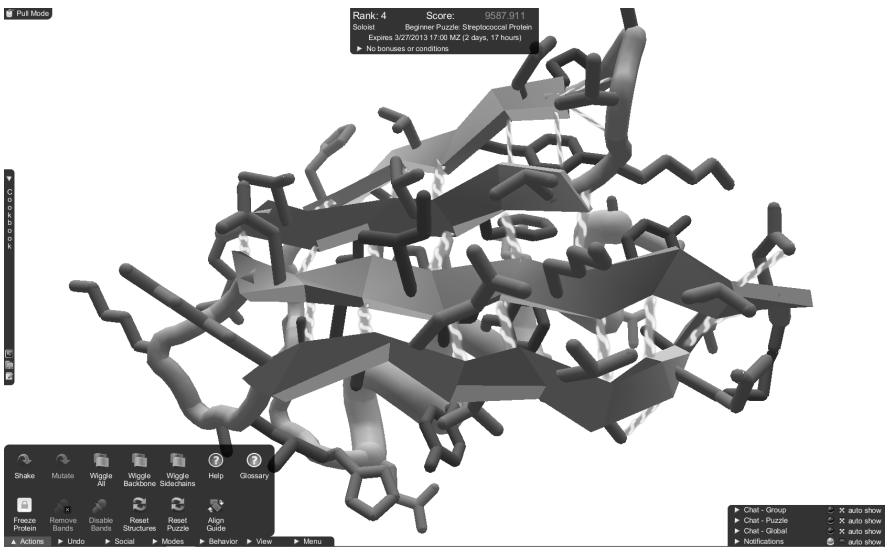

Figure 4. *Foldit*. Cartoonish look of the protein and bright colours are aimed at encouraging players (Fold.it, 2008c)

A short explanation is given on the website (with attention put to the importance of the problem to be solved), which is enough to start.

The game deals with hard problems but the rules are simple and can be worded in three pieces of advice for its players:

> **1. Pack the protein**
> The smaller the protein, the better. [...] avoid empty spaces (voids) in the structure of the protein where water molecules can get inside. [...]
>
> **2. Hide the hydrophobics**
> Hydrophobics are the sidechains that don't want to be touching water, just like oil or wax. Since most proteins float around in water, you want to keep the hydrophobics (orange sidechains) surrounded by as many atoms as possible so the water won't get to them. [...]

3. Clear the clashes
[...] [Clashes are caused by] two side chains [located] too close together [in the protein and are] represented by a red spiky ball [...] (Fold.it, 2008d).

What is really appealing, the FAQ section presents these rules also as three keywords that a player should have in mind while playing: 1) **Compact**; 2) **Buried**; 3) **Apart**.

As *Foldit* designers suggest, one of the design challenges for a GWAP is to manage and hide the complexity of the system in order to avoid a situation in which the player is overwhelmed with information (Cooper et al., 2010b). *Foldit* hides many details from the player as long as they are not necessary at a given point of a game. Protein visualisation is stylized in accordance to professional visualisation tools, but in *Foldit* it has a colourful and cartoonish look. What is more, there are customisation options available (e.g. alternative colouring schemes). As Yee (2006) points out, such an element of a game design (which seems not crucial for the game itself) plays an important role in motivating players.

4. You may (and probably should) use logic behind the game

When thinking about the game-design elements, there are certain aspects that we should particularly focus on. Namely, a well established idea of a game instance solution and the game's difficulty. These are key concepts influencing players' engagement. One of the tools you can use in order to take care about these elements is logic. We will discuss this on the example of the *Flowercode* game. The game is presented and described in detail by Gierasimczuk et al. (2013). *Flowercode* (also known as the *Deductive Mastermind*) game is a modified *Mastermind* implementation to be used within the *Math Garden* system (MathsGarden.com, 2010a). *Math Garden* is an adaptable web-based learning system consisting of several mathematical games. It is aimed at children who can play games at school as well as at home.

Mastermind is a two player game, in which the objective of the first player is to decrypt the code invented and introduced by the second player. *Flowercode* is basically *Mastermind*, with reduced complexity of the

game and with only one correct solution. Also the look and feel of the game was designed in order to be attractive for children – see Figure 5. The game is intended as a reasoning training game to be used in the *Math Garden* project.

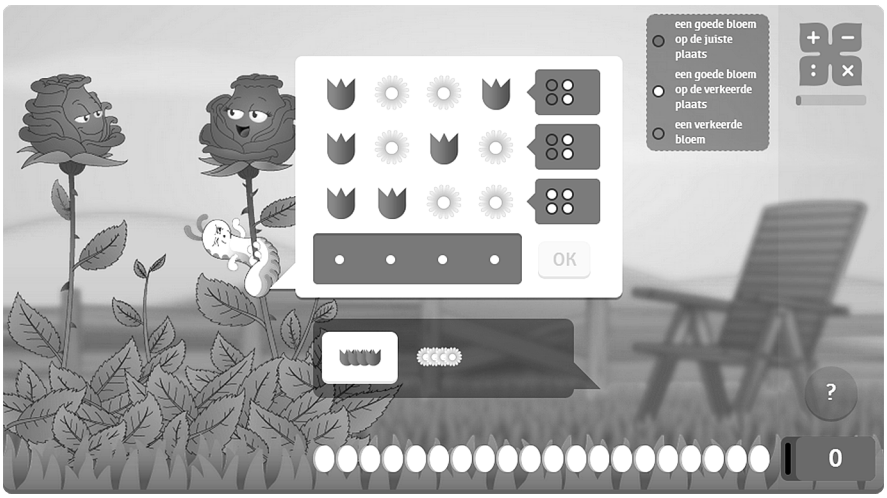

Figure 5. *Flowercode*. The game graphics is designed in order to be appealing to the target audience of primary school pupils (MathsGarden.com, 2010b)

What is interesting from our perspective is that the modelling and the analysis of the game-design uses a certain logical tool (analytic tableaux). Such a technique allows not only to ensure that there is only one correct solution to the game instance but also to predict the game instance difficulty which has reference to the empirical difficulty. What is more it also allows for better understanding of reasoning used by players in the game.

Providing the technical and formal details is beyond the scope of this paper, an interested reader may find them in the paper by Gierasimczuk et al. (2013).

It is worth mentioning that a similar approach was used in designing *QuestGen*. In the game players solve detective stories by asking yes/no questions. The underlying logical tools here were taken from the Inferential Erotetic Logic, which is a logic of questions (Wiśniewski 1995, 2013). The design of the game and discussions of the obtained results are presented in: Łupkowski, 2010; Łupkowski, Wietrzycka 2014.

5. Grasp for inspiration from other game genres – Free2Play mechanics

In the previous sections we have presented various inspirations which might be used in designing scientific discovery games. One of the possibilities, which seems to be natural, is grasping for such inspirations from other game genres. *RoboCorp* (RoboCorp, 2015) may serve as an example of such a solution. The game was designed and implemented by Dagmara Dziedzic.

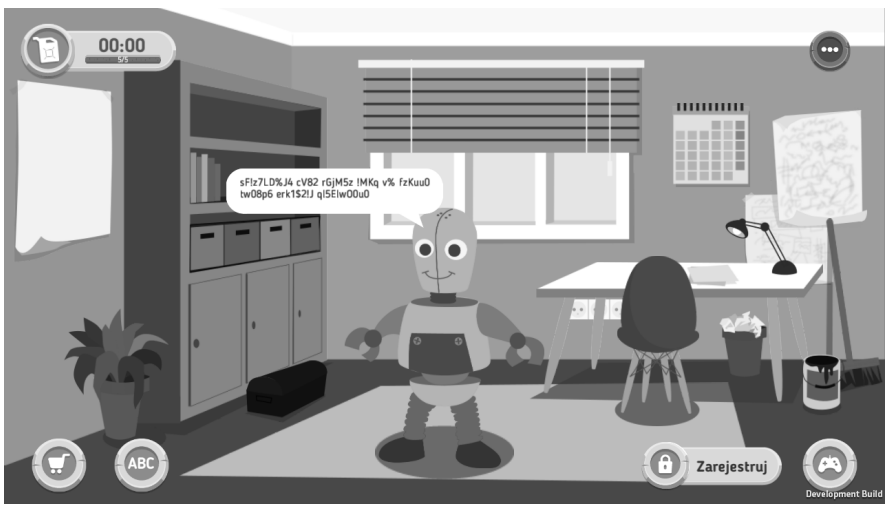

Figure 6. Main screen of *RoboCorp*. Also a mini-game, shop and the annotation module are available in the game – see RoboCorp, 2015

The main purpose of this project was to check whether the players led only by their intuition and language competence could determine named entities in the Polish sentences at least as well as language experts. The main objective in the game was annotation of the named entities retrieved from the Polish National Corpus. In order to make this process less dull and bring the playfulness to the player certain mechanisms known from Free2Play games were implemented in *RoboCorp*.

Free2Play games offer free of charge fun for players. The idea is that they can use additional features of the game design in order to encourage players to purchase items in the game. The payments are small, which

is why they are called micro-payments. Free2Play games implement several techniques which aim at improving the retention of players – the desired outcome is that players want to return to the game often. One may obtain this by introducing:

- characters and story;
- levels and levelling;
- achievements and the ways they can be shared, announced;
- additional events in the game;
- mechanisms of restricting the playing time (e.g. by introducing points of energy or other limited resources).

The main character in the *RoboCorp* game is a little robot. There is also a plot for the game. The robot cannot speak Polish. In order to communicate with him and help him get back home, the player has to annotate sentences retrieved from the Polish National Corpus (NKJP, 2008). The more named entities you will annotate, the more understandable the robot becomes. Annotation is also rewarded with points. In order to provide more fun and an opportunity to take a break from the annotation without leaving *RoboCorp* a mini-game was added. The hero of the mini-game is the robot that we already know. This is a platform game, where we try to send the robot home. In order to do this we have to gain fuel. This is also done by annotating sentences in the main module of the game. The player can also buy additional items in the game shop, where you pay using points earned during the play. So in consequence we may say that the currency in the game is not real money as in the case of classical Free2Play games, but your work (annotation). RoboCorp uses the idea which we will call micro-work (by analogy with micro-payments).

Game tests and the analysis of obtained data suggest that enriching a GWAP game with additional elements inspired with Free2Play genre makes the game more interesting and playful without any loss in the quality of the gathered data (for detailed discussion see Dziedzic, 2015 and Dziedzic, 2016).

6. Summary and discussion

Using GWAP (and more generally game-like techniques) in science is a very promising trend. Game-like solutions are attractive to non-specialists and allow to solve hard problems and collecting enormous amounts of data. The difficult task in designing this type of games is to meet two aims mentioned in the Introduction: providing an enjoyable game that still will produce valuable data as a side-effect of play. In this paper we presented certain techniques and solutions used in already existing GWAPs that might be inspiring for designing future solutions – especially when it comes to meeting the first requirement. The more GWAPs appear, the more attractive and playful the new ones should be to attract players. Also, the satisfaction from the game influences players' engagement and retention (apart from the motivation coming from the fact that they can solve a real scientific problem).

We discussed just a few games here, but in our opinion the presented ideas are, at least to some extent, universal. We may sum them up in the following short pieces of advice:

- stress that the real scientific data are used in your game;
- whenever it is possible present the data in a visual form;
- exploit simple mechanics in the game using people's natural abilities;
- think through the difficulty of the game, and whenever it is possible (and needed) define normative solutions;
- grasp for inspiration to other game genres (like Free2Play or even board games like in the case of Flowercode).

We are aware that the list is far from being complete, but we hope that it will be useful for GWAP designers in the future.

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Paweł Łupkowski, PhD – Assistant Professor at the Department of Logic and Cognitive Science, Cognitive Science Curriculum Manager at the Institute of Psychology (Adam Mickiewicz University, Poznań). Co-founder of the Reasoning Reseach Group (http://reasoning.edu.pl). Research interests: philosophical logic (logic of questions), theories of reasoning, formal analysis of cognitive processes, serious games, games with a purpose, gamification in science and education.

Dagmara Dziedzic, M. A. – Department of Logic and Cognitive Science, Institute of Psychology, Adam Mickiewicz University, Poznań. Currently, a PhD candidate at Adam Mickiewicz University in Poznań. Her scientific interests are connected with the use of games in scientific research. A large part of her research is associated with the possibility to make games used in the study both useful tool for researchers, and attractive entertainment for the player. Her work focuses on the transfer of mechanic known from traditional video games to games created for a scientific purposes. Her research is supported by her professional experience, since it is related to the design of commercial games and gamification systems.

Techniki budowania zaangażowania graczy – studium przypadku gier skierowanych na cel wykorzystywanych w nauce

Abstrakt: Celem niniejszej pracy jest przedstawienie oraz omówienie interesujących technik projektowania gier, które wykorzystane zostały w grach skierowanych na cel. Omawiane przez nas produkcje zostaną ograniczone do tych używanych w badaniach naukowych. Szczególnie ciekawą kwestię stanowi dla nas wpływ poszczególnych technik (np. implementacji mechanik modelu Free2Play) na zaangażowanie graczy.

Słowa kluczowe: gry skierowane na cel, zaangażowanie graczy, citizen science, grywalizacja, projektowanie gier