Scientific Hangman: Gamifying Scientific Evidence for General Public

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Abstract

Governmental and private funding for research in many fields has resulted in a significant body of scientific evidence. Scientific evidence or content is made available in the form of thousands of articles communicated via digital libraries. This evidence is principally used by researchers, students and on occasions for societal impact such as commercial exploitation and popular science communication. How can we gamify communicating a large amount of scientific evidence to the general public? This is the question that intrigues us. We present the game of Scientific Hangman, based on the traditional game of hangman, to communicate scientific research in a fun manner. The puzzles in our game are based on automatic summarization of scientific article abstracts. Players play the game in an attempt to guess a word given a clue such as a paper abstract. Our first prototype, was evaluated on a focus group at the Cancer Registry of Norway by communicating information from invitation letters in cervical cancer screening. We also evaluated a second prototype of the game to have feedback on design improvements resulted from the first prototype.

1. Introduction

Scientific research's output has sky rocketed in recent times. This can be seen by the huge amount of Google scholar articles which reached 160 million last year [Orduña-Malea'14] . The European Union bases its policy making based on evidence from scientific research. For instance, the European Research Council (ERC), via the Horizon 2020 program, is financing projects worth almost €80 billion over the next 7 years (2014-2020).
The purpose of such a program is to create ground for scientific research, to tackle societal challenges and to help scientific ideas fly to market[1]. Clearly, with this kind of funding in research and innovation since past many years, a significant amount of scientific evidence is being produced in the form of publications. This prompts the question, how can the society be educated about the content of these publications to give them a sense of awareness and advancement of our current understanding of the world? This will hopefully help them make better and evidence-driven choices. Answering this question is not easy because communication of scientific evidence to general public faces a number of hurdles. For instance, the high-specificity of research articles and them being addressed to a relatively small community of researchers makes scientific research increasingly hard to communicate even among researchers[2]. A contrasting example is that of multimedia content such as music or videos that is consumed relatively easily by people via services such as Spotify and YouTube.
Further, today science is affecting almost every part of our lives in a more or less unconscious way. It is very easy for a young boy/girl to use, e.g., an iPad but not knowing about the scientific achievements behind it that led to its construction. There can be huge gaps in our knowledge with black-box services that shield us from complexity. Our objective is to make an attempt in communicating scientific evidence to keep people up to date and curious about the scientific content produced at a high velocity which has been recognized as a vital need [Orduña-Malea'14] . If not for all scientific evidence, we believe that even a subset can be successfully communicated to a large audience in our informed society. We look at the domain of public health.

1.1. Background

We aim to use gamification to communicate scientific evidence. The idea of gamification is not very old, in 2008 it was documented for the first time and was well-known from the second half of 2010 [Deterding'11] . It is about using game play elements and mechanics outside the scope of games [Raymer'11] . Gamification

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[1] http://ec.europa.eu/programmes/horizon2020/en
[2] http://ec.europa.eu/research/science-society/pdf/communicating-science_en.pdf

have been useful to accomplish tasks from domains such as human computer interaction (HCI) for example image ranking upon their relevance [Lux'14] , e-learning [Raymer'11] or education because it has the potential to be helpful in engaging and motivating users towards learning activities [Borges'14] but also for increasing the productivity [Meder'14] . We use mobile platforms for this as mobile technology is also available in very remote areas. It has become ubiquitous. For instance, mobile health (mHealth) field has emerged largely in developing countries and has resulted in raising the quality and capacity of health systems [Barricelli'14] .

In this paper, we present, *Scientific Hangman* (SH), a mobile game based on the traditional game of Hangman where a player needs *to guess a word by choosing letters*. A mistake leads to the gradual appearance of a man hanging in the gallows. The player has a finite number of options before the man is hung and s/he loses the game. SH gamifies information and knowledge presented in publications in the framework of Hangman. We create game content such as puzzles from abstracts of publications via a web service and *auto summarization* of text [Nenkova'12] such as shown in section 2.1. Players are asked to answer these puzzles with the help of a clue. A clue is the abstract of a scientific article or a summary from an author. This can be perceived as cryptic by the reader but it has a different flavor when presented as a game. People will most probably like to decode an abstract to solve a puzzle in the spirit of Da Vinci Code.

We developed two prototypes. The first prototype was developed in cooperation with the Cancer Registry of Norway. The puzzles for this prototype were extracted from information letters, containing information about cervical cancer risk, to invite/remind women to come for cervical cancer screening. The idea was to use the game of SH to verify if women in a focus group truly understood the contents of the letter. We gathered feedback through an interview-based evaluation in a focus group. After considering the result of the experiment on the first prototype we concluded that the game needed improvements in terms of design and user experience (UX). To realize those improvements we developed a second prototype with similar features and purpose as of the first prototype but with sophisticated artwork and design decisions. Tests with a different test group showed us that the second prototype was received as more appealing than the first one.

The rest of the paper is organized as follows. Section 2 presents the concept from the frontend and backend perspectives of SH. Section 3 gives the details about SH prototype with the focus on design and user experience. Section 4 discusses gamification elements within the application, and Section 5 evaluates this paper with the results. We conclude in Section 6.

2. Concept

The main idea for the application is to use the traditional game of hangman to communicate scientific evidence. Hangman is a game which people of all ages are familiar with and is easy to understand and enjoyable with no sophisticated mechanics. We use Hangman in combination with the content from the research articles available online, e.g., on ACM, Pubmed and IEEE, etc. The user's goal is to find the right answer to the puzzle question in order to solve the puzzle. The user gets a clue from the research article which is the abstract and a link to the full article for the details.

2.1. Content Generation

We generated content in two different ways. (i) by applying techniques to summarize the abstract of a publication by highlighting the important and meaningful phrases in it. (ii) by providing a web-based user interface for authors of the publications who are interested in putting their work to an extended use of learning to upload some simplified version of the publication. For the auto summarization we use an already existing and well working tool.

2.1.1. Auto Summarization Tools

To choose a well working tool we performed auto summarization on an abstract [Kamangar'06] using a tool with API support if tight integration is needed. We used default settings such as *threshold* (higher the threshold value shorter the output;default 70), *minimum sentence length* (integer value;default 50), *minimum word length* (default 4) and so on but we enabled *show best words* option with a limit of 15. The extract of the abstract used is as *following*:

" Efforts to reduce global cancer disparities begin with an understanding of geographic patterns in cancer incidence, mortality, and prevalence. Using the GLOBOCAN (2002) and Cancer Incidence in Five Continents databases, we describe overall cancer incidence, mortality, and prevalence, age-adjusted

temporal trends, and age-specific incidence patterns in selected geographic regions of the world. For the eight most common malignancies-cancers of lung, breast, colon and rectum, stomach, prostate, liver, cervix, and esophagus-the most important risk factors, cancer prevention and control measures are briefly reviewed. In 2002, an estimated 11 million new cancer cases and 7 million cancer deaths were reported worldwide; nearly 25 million persons were living with cancer. Among the eight most common cancers, global disparities in cancer incidence, mortality, and prevalence are evident, likely due to complex interactions of nonmodifiable (ie, genetic susceptibility and aging) and modifiable risk factors (ie, tobacco, infectious agents, diet, and physical activity). Indeed, when risk factors among populations are intertwined with differences in individual behaviors, cultural beliefs and practices, socioeconomic conditions, and health care systems, global cancer disparities are inevitable. For the eight most common cancers, priorities for reducing cancer disparities are discussed."

The result of a good performing tool[3] can be seen in figure 1.

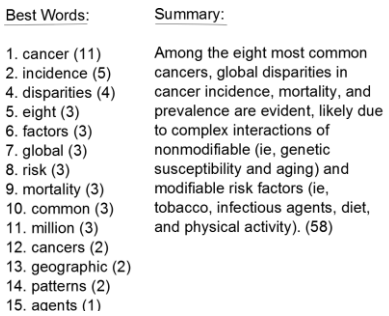


Figure 1. Well performing abstract summarization.

This summarization tool outputs a list of frequently used words along with a short text from the abstract. The words might be common such as *incidence, eight, common, million* and not very technical. However, when the words fit in as answers to the puzzle it gives a richer and more complete context. For example, in the above summary *eight* is a common word but when combined with the whole sentence it gives the information that the *global differences in the cancer occurrence along with mortality and prevalence is obvious for the eight most common cancers*.

Auto summarization facilitates creating a puzzle by suggesting best words from the abstract or any text provided to the auto summarization tool. A selected best word can serve as an answer to the puzzle. It can also help find a sentence from the abstract to be used as *puzzle insight*, mentioned in the following subsection.

Jon McLoone in his Wolfram blog post *25-best-hangman-words*[4] explains how he ran simulations of hangman game, that he built, to test words to filter out the best ones; hard to guess by the computer. Authors can chose words as puzzle answers that are shorter or have more letter repetition, as the higher frequency of repeating letters makes the longer word have different letters such as words with shorter length.

2.1.2. Web Application for Manual Content Uploading

The web based application is for the authors of the publications to upload some simplified version of the article that states the problem, scientific evidence, and the conclusion in a simple and easy to understand context with a puzzle question and the answer to it. The interface is simple and the fields are self-explanatory. We built the web application using HTML and Twitter Bootstrap with backend in node.js and the content stored in a NoSQL database - mongodb in the form of documents. We chose this technology stack because it integrates very well together. It is preferable that the content is uploaded by authors because they understand their research better and they can simplify it best to produce the game content. This is also because the quality of the content uploaded is important and we chose not to compromise on it. A text summarization API or a tool as mentioned in the previous subsection can also be used to provide authors with a useful summary or suggestions only to create game content out of their publications. To create a puzzle understanding of the publication used is important. A meaningful puzzle will be the one which has maximum information flow. This can be done best by the author of the publication itself because of the fact that they understand their research, its evidence and conclusion better. We decided to allow the content from

[3] https://www.tools4noobs.com/summarize/

[4] http://blog.wolfram.com/2010/08/13/25-best-hangman-words/

publications that are peer reviewed only and also the process of uploading stays moderated to assure check and balance on the quality. The system administrators goes through the content, checks all the parameters before approving it. Once approved, the author gets the notification.

The prototype of the interface can be seen in Figure 2. To create the game content author must provide information such as *paper name*, *paper abstract*, *article URL*, *puzzle question*, *answer* , and *puzzle insight (*few lines of text that could motivate/attract the user to this puzzle*)*. The author can ignore the optional field such as *puzzle clue*. The *clue* if ignored will take *paper abstract* as a default value. The link to the summarization tool is also given for the authors who wants to get suggestions on the best words and useful summary from a large piece of text.

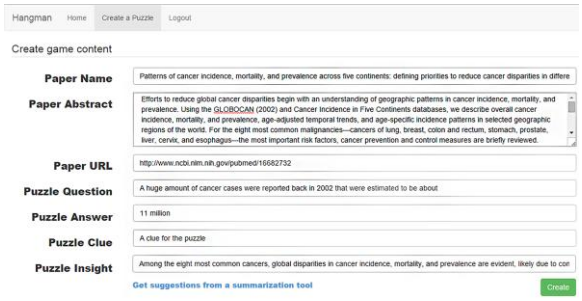


Figure 2. Puzzle creation screen that can be used by the researcher to feed content into the game system.

2.2. Content Utilization

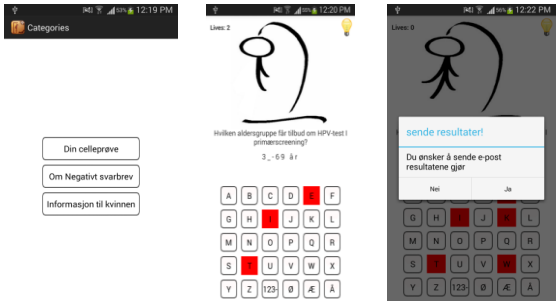
As stated before the research literature uploaded either by the authors or by using text summarization is used as game content. This content could also be used in combination with other popular game concepts like (i) *Typing Master*; where a player is displayed with words and sentences from the simplified version of literature to increase their typing speed and accuracy which effectively makes them read the content as they type, (ii) *Scrabble*; where players can be asked to sort the letters that form proper words but within the scope of the information given in this case the simplified scientific knowledge and (iii) *Multiple Choice Questions*; by displaying a question and multiple answers to it and asking users to read through the simplified information presented as a clue to answer for rewards. We chose Hangman because it provides simple mechanics and involves less effort at player's end yet the information is effectively transferred by the help of clue for the puzzles. The puzzle question is presented and the user is asked to answer it by reading the clue in the form of summarized information. The user goal is to answer it correctly in order to save the man hanging and to get points. We decided to display a puzzle insight, some interesting piece of text from the scientific article, to the user before s/he accepts to play. Example from the same abstract used in section 2.1.1 a puzzle insight can be, *in 2002, an estimated 11 million new cancer cases and 7 million cancer deaths were reported worldwide; nearly 25 million persons were living with cancer*. This helps the user to save time on making the decision to accept the displayed puzzle and helps us in least information flow if user decides to skip the puzzle. The content being used can be seen in the next section.

3. Design and User Experience

Scientific Hangman, based on a traditional hangman game for information flow by using the content from research articles, goal is to make scientific literature interesting as well as easy for the general public to understand. For this purpose, the design should be simple yet appealing. We went through multiple iterations for the designing of the application which resulted in two prototypes that were used in user studies.

3.1. First Prototype

For the first prototype we decided for a simple black and white application with very simple workflow. The game was designed for a specific application at the Cancer Registry Norway. Therefore the information and puzzle questions were in Norwegian. As development platform we used Android because of its openness. Figure 3(a,b,c) below show the look and feel of the game. The reason for keeping it simple was based on the fact that scientific literature is not easy to understand. To make it effectively delivered we must take a simple design approach to deliver the important part, the scientific knowledge, without any disturbance by the design parts.



(a) **(b)** **(c)**

Figure 3 (a) Information letters as categories, (b) Gameplay screen with puzzle question, (c) Result submission

3.2. Second Prototype

To make improvements in the application design, in the 2nd iteration, we decided to create a user experience in terms of look and feel which is more appealing, not too bright and not too dull. As this app gamifies content for learning purposes we chose the old fashioned blackboard theme for it because blackboards have been heavily in use in the past at primary and secondary level of education. We sketched all the elements with a chalk on a rough black sheet of paper to keep the look natural and uneven and sliced the elements using Adobe Photoshop. The rough and natural look of the game can be seen in Figure 4.

(a) (b) (c)

Figure 4. (a) Home screen with an awareness meter (b) Insight to help user decide (c) Gameplay screen with puzzle question

First prototype was tested at the Cancer Registry of Norway. We gathered feedback on the look and feel of both prototypes. We discuss the test details, results and the feedback in section 5 of this paper.

4. Gamification Elements

We present the information to be learned in a way where user has some goal to achieve such as completing the puzzle and getting a reward/point/badge. The points are based on time and the number of mistakes the player makes to guess the answer. Secondly, the user is displayed the completeness by using a progress bar, we name it as an *awareness meter* meaning how aware has user become by solving the puzzles based on the research articles.

Displaying information at the right time and place can help in bringing motivation in the player. Leaderboard in iOS games is used to display high score information. This is usually displayed at the end of the level or game. We chose to display such information at the time when user is making decision on playing the puzzle presented. The information of user's friends related to the puzzle such as, the no. of tries they made in solving the puzzle, whether they solved the puzzle or failed and their awareness level, beforehand, can help in motivating the user to play the puzzle with increased interest. This kind of information on points and number of wins (leaderboard) also brings the sense of competition between users[5]. This feature will be part of the second application which is still under development.

We also chose to gather feedback on the puzzles, asking user if s/he knew about the information in the puzzle before and how well the information was understandable. This increases users engagement with the app, gives them the sense of being an integral part and not merely a subject and creates their connection with the designers [Salvo'01] . This also helps us gather stats on the usefulness of this application.

We recorded the time spent on solving the puzzles. It gives us information on user behavior such as whether it was easy for them to locate and understand the information required to answer the puzzle question.

[5] http://insights.wired.com/profiles/blogs/is-competition-discouraging-the-linkedin-example

5. Evaluation

5.1. First Prototype

Prototype 1 was tested at Cancer Registry of Norway with a focus group where 10 women participated. We presented three different information letters to the women. The letters contained information regarding cervical cancer screening. One letter was to invite women between 25 and 69 to a cytology test[6]. A second letter was a reminder letter for attendance. Although the letters were not scientific articles, they were often ignored by recipients due to some of its technical content. The game was installed on a single Android device and was projected at a bigger screen for every participant to see. The women were separately given the smart phone and were asked to answer the questions based on the information they received earlier in the letters which was also present in the game in the form of clue. They could read the information as many times as they wanted within the game. We recorded the steps the women performed during the game for example how many times they opened the clue window to read the letters, how many right/wrong entries they made and the time they spent on answering the question. The purpose was to test their knowledge from those letters, to see how well they received the information mentioned in the letters.

The information letters were short and less technical as compared to scientific literature. All 10 women submitted the answers and were able to answer all of the puzzle questions in the game correctly, more or less consuming the same amount of time. This showed that the information flow was good and that the participating women understood the information.

After the experiment we evaluated that the participants paid attention to the information letters to answer the puzzle questions because the information flow was created in the form of an interesting activity i.e. a game.

We learnt that design matters to the user interacting with the game. Design should be appealing to generate a positive emotion which as a result can trigger increased interaction. The first impression of this prototype in terms of design was not very positive. Participants were told that it is a game but they perceived it more like an application rather than a game. The sense of achievement is critical. The harder the effort on achieving goals more likely it is that the user will lose interest. The goals must be according to the skills of the users to keep them interested. That means the information should be simplified enough so that the user do not lose interest. For example, the content used in this prototype was from the invitation letters, as stated above, having simple and less technical information. The women found the information easy to understand which was also evaluated by the results they submitted through the game.

5.2. Second Prototype

Prototype 2 is more general and conceptually covers a wider scope as compared to prototype 1. The basic feature set and purpose is similar i.e. to use scientific literature as puzzle questions to make the flow of scientific information easy as well as interesting for people. The feature set is under development with the idea of employing gamification elements mentioned above to increase engagement and user motivation for better reach. As explained in section 2, the content for the second prototype will be generated by using the web application that has been developed for the authors of the publications to upload their research results. Also test summarization tools can help the authors to summarize their research results and to highlight important words in the text. All this content will be used in this prototype as a puzzle which a player can solve by reading the clue in the form of abstract or relevant information uploaded by the author.

We explained the details of the content generation through the web panel and text summarization tools and presented the idea of the game in the form of second prototype to a total of 8 colleagues and friends. This activity was to get their feedback on the design improvements only, as the functionality is not yet developed but will follow the same course as of the first prototype in terms of the nature of the content i.e. publications uploaded by the authors using our web application.

We decided not to tell the audience about the developers of the second prototype to have an unbiased feedback. We asked them what they think of the look and feel and whether they would play such a game or not. Before having answers we showed them the first

[6] http://www.cancerresearchuk.org/about-cancer/type/cervical-cancer/about/cervical-cancer-screening

prototype so that they could compare both the versions in terms of design and user experience.
All of the participants chose the design of the second prototype over the first one. They were more inclined towards the second prototype design and found it appealing. This was due to the rough look and feel of the art work because it was hand drawn on a black sheet of paper using a chalk. The first prototype, was dull and not attractive to them. Moreover, we asked them to play the first prototype to have their feedback on the functionality as well. We asked what they think of the game and the idea on which they gave positive impression on the nature of the game because they were able to understand and get the information out of the letters in the first prototype to answer the puzzle questions. One participant for example responded that,
"Although the information is not very much interesting but I am challenged to find the answer which makes the game interesting to me."
Another interesting response was,
"It is interesting to figure out what is written in the information letter which I believe I was unaware of."
This showed us that the game could motivate them to do a boring task and that the information in the letters could be communicated in an understandable way.

6. Conclusion

We make use of mobile platform to deliver simplified scientific knowledge to the general public for increased science awareness and to communicate information in a better perceived way. Our evaluation showed that this can have many benefits. For instance, the user, a father, might be able to do some counseling of his children and motivate them towards science if he has better understanding. He might be able to understand the environmental changes, the societal challenges, the medical breakthroughs and discoveries. Such simplified information presented through gamification methods with a touch of fun and entertainment could result in improved awareness in general public. This also puts the scientific research to an extended use, from online libraries in peoples' hands.

From the experiment at the Cancer Registry of Norway, the interest of medical professionals at the registry and the interview based evaluation from individuals we conclude that the concept has the potential of delivering and testing the information flow of scientific nature such as from publications. We also see how hard or easy it was for the people to comprehend the text and understand the questions and answer them correctly. The game was used as a means to evaluate the text in the letters that is sent to several thousands of women. There is already a huge amount of publications stored in the digital libraries which can be used by employing text summarization techniques and to create game content manually in a moderated environment to ensure quality in terms of engagement.

User's feedback is critical and can be used to give researchers a new index to see the impact of their research. Feedback can tell how useful or understandable the information was. This also needs focus on what parameters are important and carry maximum information.

Technical information is usually ignored by the general public due to the lack of interest or the complex nature of it. The information displayed at the right time during navigation within the application can help in getting user's attention. For example in a game, Jelly Splash[7] high score is displayed at the time of level selection and not at the end. It gives user the information on high scores before starting the level which could help in motivating the user to play carefully to beat the best player. To help it further, work needs to be done for improved design choices in terms of information presentation to maximize information flow in combination with gamification techniques.

For future work we plan to use gamification methods to create incentives for authors of scientific publications. These techniques can be used in a wider scope. For instance, a web based application with gamification elements to motivate *researchers* to bring the simplified version of their research forward for the use of general public. This simplified content, as explained above, can become food for many game ideas that can help general public in understanding the research.

Finally, we are interested in using this platform in the future, to see how research related to domains such as health can be communicated. Since it is a very interesting area by nature and therefore it does not need a lot of motivation. Moreover this area can be easily personalized and learning about personal health choices can benefit the majority.

[7] http://www.wooga.com/games/jelly-splash/

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