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Gamification, citizen science, and civic technologies: In search of the common good[1]

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ABSTRACT

In this paper, we discuss the importance of gameplay as a valuable tool in citizen sensing initiatives aimed at enabling creative collaboration and civic engagement. We present a review of selected citizen science and civic technologies' projects highlighting an emerging culture of massive collaborative initiatives that make use of crowdsourcing, enabling users to voluntarily contribute with their time, effort and resources towards scientific research and civic issues. Moreover, we discuss how these initiatives could benefit from the inclusion of gameplay in their interaction processes. For that matter, we present a gamified citizen sensing project we are devising for users to enter and retrieve information on commercially available food products which contain ingredients associated with an increased risk of cancer and other diseases. Through gameplay, we expect to crowdsource an open database of potentially unhealthy food products, raising awareness among consumers about the risks of certain artificial additives. Finally, we argue that the use of gamification processes can engage voluntary participation in initiatives aimed at citizenship – including those which demand complex and repetitive tasks for the collection of data – and call for a more ethical, critical, and meaningful use of these new potential technologies, and for greater awareness of our new civic responsibilities.

Keywords: interaction design, gamification, citizen sensing, mobile applications, artificial food additives.

Introduction

As foreseen by Mark Weiser over two decades ago, computer devices and systems have become intrinsically and transparently integrated into the fabric of our human existence (Weiser, 1991). Ubiquitous mobile technologies have intertwined our physical and digital realities, creating new hybrid experiences and expanding both our individual and social frontiers. Our information and communication technologies are now "worn on our skin" (Kozel, 2013, p. 338). Connected and combined through invisible nets which organize us into groups, collectives and tribes, we have become more socially engaged beings, who communicate with our friends in a fast and uninterruptedly way by means of tiny emoticons and monosyllabic expressions, and are constantly willing to debate, discuss, organize and share our ideas and our actions within our communities and networks (Spitz, 2014). Smartphones have become affordable to more people around the globe – by the end of 2017, over 5 billion users had a mobile in their pockets, according to a study recently released by GSMA Intelligence (Sivakumaran and Iacopino, 2018) – and have gained substantial relevance in everyday life, as they become integrated in all social environments and are used "to help address the challenges of access, cost and quality of service in key industries, including healthcare, agriculture, utilities, education and financial services" (Sivakumaran and Iacopino, 2018, p. 4). Thanks to the use of positioning systems and sensors, the growth of networks for wireless communication, as well as the increasing offer of applications and functional items, the amount of personal data and information gathered by these mobile devices is multiplying at an incredible rate. And if in the first decade of the 21st century much of individual social interaction was mediated "by sorting algorithms from recommended movies to selected books, music, and even lovers" (Searle, 2015, p. 3), with the fast growth of ubiquitous computing – which took place during this second decade – ordinary devices and technologies not only became smart and more attractive to users, but also much more pervasive. Information

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concerning the habits of individuals – collected in a much greater detail and depth – is now widely available and can be used for different purposes. "Queries on search engines, status updates, friendship connections, preferences generated in social media, geolocation data from smartphones, purchasing history, and more provide businesses, governments, and scientists a wealth of insights and a new way of understanding the world" (Goni, 2016, p. 324). Cross-linking of different data sources provides deep insights into issues such as personality, health, commercial intent and risk. The aim now is to understand and characterize the population, down to the individual level. Although the power of accumulated capital can still play a major role in international economic affairs, a new form of power is emerging in our digital society: data is our new currency (Lawrence, 2015).

Tethered to our mobile gadgets and connected to our social networks on a full-time basis, we have become a major source for sensing, collecting, retrieving and sharing all kinds of information about the universe, with or without our intervention or awareness. "By far the biggest generator of data is all of us, people. Increasingly, everything that we are, as physical, emotional, thinking beings, is reflected digitally; our behaviors, our habits, our DNA, our passions, our relationships, our dreams" (Deakins, 2016, p. 1).

This scenario not only raises concerns about privacy, surveillance and ethical issues, but also calls for a more critical and meaningful use of technology, as well as greater awareness of our new civic responsibilities.

Citizen Sensing

While driving in the streets of our cities, or taking pictures and posting comments using apps and social media, we are constantly sharing our locations and geotagging our lives. Citizens have become "sensors" – unconscious and passive data sources – knowingly or not (Berg, 2013). This undisclosed extraction of data from people, either for surveillance and control or for commercial purposes, has raised ethical issues about the responsibility of autonomous computer systems (Hilty, 2015; Machidon, 2015), and the impact of objectification and classification of human beings (Searle, 2015). "Sensing" – defined as the ability to measure what happens around us and to respond dynamically (Ratti, 2014) – has become crucial to our data-driven society.

Physical sensing technologies are increasingly being used in urban infrastructures making up the basis for different initiatives under the Smart City paradigm (Gibson *et al.*, 1992). On the other hand, citizen sensing technologies could also play an important role in the development of intelligent urban infrastructures "since they enable the collection of several types of relevant data that cannot be properly captured by traditional physical sensors" (Gallo *et al.*, 2014, p. 4154).

Gallo *et al.* (2014, p. 4154) define citizen sensing as "a new sensor-based data collection paradigm that is focused on the extraction of data generated by people". In their view, "any organized means of getting information from citizens and their interactions with the city can be interpreted as citizen sensing". They have proposed a taxonomy to classify and organize different types of citizen sensing projects according to their data collection methodology. Their taxonomy provides a framework for analyzing citizen sensing projects according to issues related to user interaction (whether the user is passive or active), issues related to user awareness (whether the user is conscious or unconscious of the purpose of the data being collected), as well as issues related to motivation and privacy.

In fact, many mobile applications have been devised over the past few years, allowing people to share their information, opinions, preferences and needs with their friends and communities But if, on the one hand, some applications are sensing involuntary and unconscious activities of people who are unaware of both the data they are providing and its end results, on the other hand, an increasing number of initiatives are developing sensing applications where citizens collaborate by choice with the aim of achieving specific results in the interest of their own communities. In recent years, a significant number of citizen sensing applications are being developed as civic participation platforms. Citizens themselves are increasingly taking an active role in participatory data sharing initiatives for the benefit of their own communities, neighborhoods or cities. These initiatives are enabling new kinds of social innovations.

Digital social innovation

Social innovations are characterized by "innovative activities and services that are motivated by the goal of meeting social needs and that are predominantly developed and diffused through organizations whose primary purposes are social" (Mulgan, 2007, p. 8). With the emergence of open technologies such as open data, open hardware and open networks, a growing number of organizations in civil society are now relying on digital technologies to develop innovative services to address social challenges, characterizing a broad range of digital social innovations (Bria *et al.*, 2014).

Manzini (2015) has emphasized the impact of digital technologies in social innovation processes:

> *In the past decade, the diffusion of the Internet, mobile phones and social media, converging with social innovation, has enabled the creation of a new generation of services that not only offer unprecedented solutions to difficult social problems but also challenge our ideas of welfare and the relationship between citizen and state (Manzini, 2015, p. 4).*

Led by collaborations between open government agencies, non-governmental organizations, research institutes, urban labs, makerspaces and grassroots communities, digital social innovation initiatives are proposing new forms of common cultures, based on open technologies and open knowledge, fostering new forms of democracy, as well as opening new grounds for participatory design explorations (Pereira Junior and Spitz, 2017).

These initiatives that are using digital technologies to foster civic engagement, with citizens working together and using their knowledge, skills, values and motivation to make a difference, to promote quality in the life of their communities. These initiatives are targeting social challenges through collective action and active participation in the formation of shared knowledge, aiming at the common good.

Citizen science and civic technologies

A growing number of digital social innovations using citizen sensing technologies can be observed in citizen science and civic technologies initiatives.

Civic technologies are digital solutions specifically created to enable and facilitate civic participation in public administration. Civic technologies have emerged from open government initiatives, led not only by government organizations but also by civil society organizations. They comprise a convergence of fields intertwining domains such as government transparency, community organizing, peer-to-peer sharing and collaborative consumption, crowdfunding of public services, place-based networks and community forums (Patel *et al.*, 2013). Although a number of commercial entrepreneurs are venturing over the "civic tech" domain, with proprietary platforms, most interesting social innovations are coming from civil society organizations, making use of open technologies (Pereira Junior, 2017).

Examples of social innovations making use of citizen sensing techniques within the scope of civic technologies include, among others: public decision making platforms such as LiquidFeedback (http://liquidfeedback.org) from Germany, Democracy OS (http://democracyos.org) from Argentina, and Mudamos (http://mudamos.org) from Brazil, targeted on citizen participation in deliberative democracy processes; citizen feedback platforms such as FixMyStreet (http://fixmystreet.com) from the United Kingdom, and SeeClickFix (http://seeclickfix.com) from the USA, targeted on resident feedback about public services; information crowdsourcing platforms such as Ushahidi (http://ushahidi.com) from Kenya and Local Data (http://localdata.com), from the United States, a former Code for America project.

Citizen science initiatives empower citizens to engage in collective action through grassroots science across their neighborhoods, cities and nations, exploring smartphones and other kinds of sensor technologies such as personal measurement instruments capable of sensing our physical environment (Paulos *et al.*, 2009). Citizen scientists are individuals who voluntarily contribute their time, effort, and resources towards scientific research – either in collaboration with professional scientists or alone – but do not necessarily have a formal science background.

Examples of social innovations making use of citizen sensing techniques in citizen science initiatives include: Smart Citizen Kit (http://smartcitizen.me), a crowdsourcing platform for measuring environmental data with experiments in Amsterdam, Manchester, Glasgow and Barcelona; Safecast (http://safecast.org), a volunteer-centered citizen science project launched after Japan, 2011 earthquake and tsunami and the subsequent accidents at the Fukushima Daiichi Nuclear Power Plant, to monitor, collect, and share information on environmental radiation and other pollutants. Another relevant example is Rede InfoAmazonia Mãe D'Agua project (http://publiclab.org/wiki/mae-d-agua), a network of low cost sensors distributed to citizens who live alongside rivers in the Amazon region for collecting data on water quality of rivers, wheels, and springs.

Play and gamification

A core element in many civic technologies and citizen science initiatives is motivation. Users should be motivated to participate in large-scale data collecting processes. Play can be a valuable means to stimulate motivation and engagement of participants. The act of playing can enable the creation and discovery of new and unique experiences. "Everyone who plays a game puts a little of themselves into the experience, and takes away something that is wholly unique" (Smithsonian American Art Museum, 2009).

Gamification – "the use of game design elements in non-game contexts" (Deterding, *et al.*, 2011, p. 10) – is widely applied in several different areas to foster learning and engagement. Frequently based on structural game design elements such as points, badges, levels, and leaderboards – but also resorting to game-like aesthetics, interactivity, and visual stimuli – gamification has been applied to science education (Simmons *et al.*, 2015) and citizen science (Bowser *et al.*, 2013; Morris *et al.*, 2013), where it has been used to reshape monotonous tasks into compelling experiences (Franzoni and Sauermann, 2014). Citizen science initiatives, then, engage large audiences within the general public, crowdsourcing data collection (MacDonald, 2015) and human problem-solving skills in ways it can be more efficient than computational resources (Cooper *et al.*, 2010). Perhaps more importantly in the context of the present study, gamified citizen science can introduce scientific facts to the general public, informing them on complex and important issues – while involving the public in the expansion of knowledge in scientific domains (Devlin *et al.*, 2014). Citizen science, then, has been very successful in, at once, engaging the public in scientific enquiry and generating relevant academic contribution (Simmons *et al.*, 2015).

Gamification processes have been widely used successfully in the engagement of voluntary participation in initiatives aimed at citizenship and also in the collection of diverse data. Through the use of game design elements, such initiatives are able to stimulate from the reorganization of neighborhoods (Claeys, 2013), Civic Media Platforms (De Paoli *et al.*, 2012) to the mapping of noise pollution levels (Martí *et al.*, 2012). In addition to facilitating and motivating participation, such processes promote loyalty, or a prolonged engagement, seeking to insert users/players in surrounding dynamics, in addition to highlighting the significant character and real impact on society of their contribution.

Development of Dyet (Do you eat this?)

Considering the background discussed in the previous sections, we started the development of Dyet, a gamified citizen science collaborative project, aimed at raising awareness about the risks of the excessive consumption of artificial food additives in our daily life, by means of engaging citizens in crowdsourcing an open database of unhealthy food products. The project is being developed as part of the research activities being conducted by the Laboratório de Arte Eletrônica at PUC-Rio, in collaboration with Instituto Tecgraf, with the support of Fundação de Amparo à Pesquisa do Rio de Janeiro (FAPERJ). Dyet will be a gamified smartphone app, where citizens can enter and retrieve information on commercially available food products which contain ingredients associated with an increased risk of cancer and other diseases. Through gameplay, we expect to engage citizens on an important public health issue, and to raise awareness about better nutrition habits.

Design process and methodological aspects

The project originated from our desire to combine the diverse professional and academic expertise of the members of our lab – an interdisciplinary locus where undergraduate, graduate students and faculty meet to reflect, research, create and produce Art & Design projects with emphasis on the use and development of digital technologies adapted to different contexts, considering their impacts on society and on the natural environment. Since its creation, in 1992, Laboratório de Arte Eletrônica has adopted a work methodology which has rigorously been maintained until today: all the team members participate in all phases of the projects, performing different activities and contributing in different areas, thus having a holistic view of the project.

The list of areas of expertise and interests of the team included game design and gamification, scientific software, education, crowdmapping, citizen science, intelligent citizens, civic technologies, mobile applications, and audio-visual-haptic interface design, and we discussed possible project proposals that would encompass all those areas.

We were also interested in the use of different forms of digital intelligence (physical sensing, artificial intelligence, data analytics, big data, internet of things), on aspects of community engagement in governance and decision making processes, civic participation and co-design processes, such as e-democracy, e-participation, e-governance, open innovation and open government.

Considering the diverse interests of our team and the challenge to embed gamification methods in our design process, we did not adopt any specific gamification framework, but rather followed a design process similar to the ones proposed by Marczewski (2013) and Vianna *et al.* (2013). As shown in Table 1, the frameworks proposed by these authors consist in a few generic design phases, such as understanding the problem and the users, ideation and prototyping, testing and feedback, implementation.

Our design process consisted on the following phases: goals and problem definition; game design; initial testing; analysis and feedback. We are currently developing a new prototype for further testing before devising a fully-implemented product.

Goals and problem definition

Following initial discussions about our team motivations, we decided the goal of the project would be to investigate the use of digital media in processes of civic engagement and construction of digital citizenship in the context of intelligent cities, focusing on how gamification and autonomy in data collecting, processing and analysis can empower bottom-up initiatives. But we still needed a specific theme to address, and another converging topic of interest in the group was "healthy eating". Many team members expressed their concerns on the abusive use of pesticides in agriculture (Myslinski, 2015; Campanha Nacional Contra o Uso de Agrotóxicos e pela Vida, 2012), and the inclusion of artificial additives in food products (Stevens *et al.*, 2014), both in Brazil and abroad. We found out that, although the list of ingredients is printed on the package of all commercially available products, such information is neither fully legible (the print is usually far too small), nor intelligible (the use of scientific names of the ingredients makes it impossible for the average citizen to decode the information). Moreover, the average person does not have access to information on the dangers and risks involved in the consumption of certain ingredients, and should be better informed about those facts by the industry and state. Although food labeling is subject to strict standards and legislations from health and sanitary surveillance agencies, most information is still unsighted to the general public. The bar code – which is printed in every product packaging – enables access to a global database with product information. However, that information is not available to consumers. Instead, it mainly serves the purpose of speeding the process of registering the sale of the product and generating its final price at the market's cashier. Indeed, not only it is difficult to know what are the exact ingredients which your meal contains, it is also hard to find intelligible, comprehensible and reliable information on what are the pros and cons of ingesting them, in terms of their nutrition and health impact. We approached the researchers at Fundação Oswaldo Cruz (Fiocruz) – the most prominent science and technology health institution in Latin America, attached to the Brazilian Ministry of Health – and asked for their guidance on what would be necessary information to crowdsource. They have suggested a list of ingredients and additives which can cause serious health problems, and highlighted

Table 1. Gamification processes proposed by Marczewski (2013) and Vianna *et al.* (2013).

Marczewski (2013)	Vianna *et al.* (2013)
1. WHAT we are going to gamify	1. Understanding the problem and the context
2. WHY we are gamifying it	2. Understanding who are the players
3. WHO will be the players	3. Defining guiding criteria and game mission
4. HOW we are gamifying it	4. Developing ideas for the game
5. ANALYTICS set up	5. Definition of the game mechanics
6. TESTING with users	6. Low, medium and/or high fidelity testing
7. ACTING on feedback	7. Implementation and monitoring
8. RELEASING the solution	8. Measurement and evaluation

the risks of artificial food additives, which have absolutely no nourishing attributes but are increasingly being added to most industrialized food products we buy daily, with the sole intent to modify their physical, chemical, biological or sensory characteristics, making them more appealing to consumers, thus increasing the sales and augmenting the profit of the food industry.

Over 6,000 artificial additives are customarily employed by the food industry and largely consumed by people around the world. Their increasing use by the industry causes great concern, since excessive consumption of artificial food additives can produce adverse reactions and lead to irreversible illnesses, as pointed out by scientific studies (Fai *et al.*, 2008; Grier *et al.*, 2007; Nascimento *et al.*, 2016; Stevens *et al.*, 2014). Artificial food dyes are especially dangerous, since – although they can impair children's behavior and cause serious health diseases (Center for Science in the Public Interest, 2016a, 2016b; Prado and Godoy, 2003; Rosenthal, 2007) – they can be commonly found in most candies, cookies, soft drinks, chewing gums, jellies and other food products marketed to children and teenagers. Although it has become practically impossible to avoid consuming artificial food additives in our daily life – due to the great number of industrialized products containing them – most consumers know very little about these artificial food additives and the harm they cause to people. As our society advances towards more government and corporate transparency, we should demand more accessible and intelligible food labeling information.

Game design

Considering the game design perspective, we have envisioned the application as a location-based game, along the lines of Niantic's *Pokémon Go*, in which players are challenged to actively search for objects by moving around in the real world, if necessary (Figure 1).

The game dynamics can be summarized as the following: (1) players are presented visually compelling information about a harmful ingredient that must be searched for; (2) players look, in the real world, for products including that ingredient; (3) players scan the barcode of such products; (4) if required, players enter additional information about that product; (5) players send the gathered information to a database of potentially harmful products; (6) players are rewarded for their contribution with points and visually stimulating illustrations based on and inspired by the data they have submitted.

The design process for elaborating the app's dynamics took approximately three months and involved eight members of our lab. After brainstorming our conceptual goals, discussing possible alternatives and sketching our initial ideas (Figure 2), we created a narrative (in the form of a storyboard) and started to layout design alternatives for the app (Figure 3). Finally, the first version of the user journey was mapped, giving the team a clear overview of the player's journey through the app (Figure 4).

Given the plurality of visions and diversity of backgrounds of participants, we resorted to Playgen's Adding-Play gamification framework to assist with the process. As proposed by that framework's play card system, we have discussed players' motivation, game mechanics, social mechanics, and victory conditions (Figure 5).

Initially worried about having the creative process excessively constrained by the framework, we actually found it a valuable tool for generating ideas and establishing a common ground for a discussion through which we could prioritize features, identify necessary game design

Figure 1. Scanning the barcode.

Figure 2. Initial brainstorming and sketches.

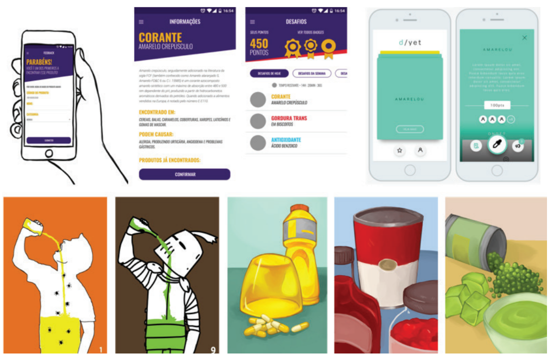

Figure 3. Layouts of design alternatives.

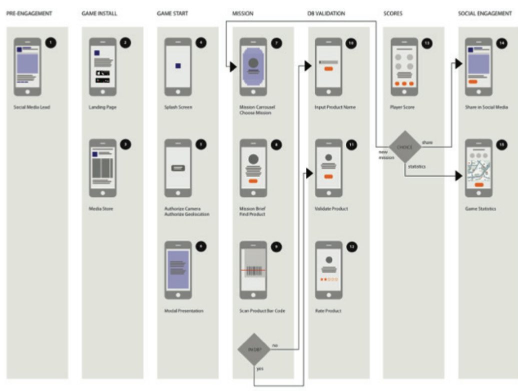

Figure 4. User's journey map (first version).

elements, and start establishing gameplay dynamics and mechanics. Although some of those features have been subtracted to the final design, others were kept as the core of the intended player experience, particularly the ones highlighted in Table 2.

The game follows the overall structure of a scavenger hunt, where players must search for listed entities (food additives), occasionally under time pressure. Additionally, there is a collectible aspect to the game, as players accumulate cards that illustrate the missions, or 'quests', they have completed. The design process for establishing the game's dynamics and mechanics was not based on any specific framework, being rather structured over the project needs (population of database) and game design elements often used to reward users' input (such as points, leaderboards, and collectibles). Equally important was the search for, as defined by Popa, "better emotional experiences" from "cross references from games" (2013, p. 8), which explains the influence of games such as *Pokémon GO* and *Magic: The Gathering* over preliminary versions of Dyet.

From the start of the design process, we had in mind that we wanted to appeal to a wide range of demographics: not only health-conscious consumers and politically engaged individuals, but also casual players looking for a game to spend some time with. We believe we could approach different types of player motivations – from extrinsic rewards and scoreboards to an intrinsic sense of purposefulness – that could foster civic engagement in citizen sensing initiatives like the one we are now devising.

Through gameplay, we expect to crowdsource an open database of potentially unhealthy food products, raising awareness among consumers about the risks of certain ingredients and artificial additives.

Figure 5. Game design organized in Adding Play framework.

Initial testing

Once we had established the basic gameplay, we organized a testing session through which to assess the efficiency of the game design at engaging players in the collection of data while sustaining a sense of fun. The test involved two different groups of participants: the first one was composed by 8 undergraduate students (ages ranging between 18 and 25 years old). The students were all single, still living with their parents or relatives, and did not have children. In terms of gender, 6 of the students were male, 1 was female and 1 was transgender. The second group was formed by 4 professionals: 3 of them were digital media educators and 1 was a computer scientist. They were all male, ages ranging from 30 to 45 years old. Only one of them was single, the other 3 were married and had small children. All the test participants were frequent users of social media and mobile technologies, and very savvy on the use of digital media interfaces. All participants were game enthusiasts and familiar with the medium.

Prior to the test, we asked participants a few questions on their knowledge, interest, and concern on the major issues related to our project. As far as their level of interest on the topic "healthy eating" was concerned, 3 test participants responded "none", 4 responded "very low", 1 responded "average", and 2 test participants responded "very high". In terms of their degree of perceived knowledge about the harm that excessive intake of artificial food additives can cause to our health, all the students responded "very little", while the group of professionals responded "high" or "very high". Respondents who have children not only shared their worries about the potential harm those additives can cause to their children, but talked about their individual rules and actions to prevent their kids from eating unhealthy food. They were clearly more aware of this subject than the students group.

For this preliminary testing session, we have not developed a prototype, relying on pre-installed apps available from testers' mobile phones. To compensate for the lack of functionality regarding barcode recognition, the group of twelve players were divided in six groups of two, so they could enter and send the gathered data quickly.

Table 2. Relationship between AddingPlay's cards and Dyet features.

Category	Card	Game experience
Motivators	Meaning	Contributing to awareness and information on potentially dangerous products.
	Curiosity	Finding out which products contain additives.
Victory Conditions	Goal/Objectives	Scanning and submitting products containing a specific food additive.
	Victory Points	Accumulating scans of products containing a specific food additive.
Game Mechanics	Quest	Finding a number of products containing a specific additive over a specific amount of time.
	Score	Accumulating points awarded in quests.
Social Mechanics	Collecting	Collecting mission cards after completing quests.
	Leaderboard	Comparing performance to other players'

Figure 6. Sample cards from gameplay testing session.

The rules of the game for that testing session were as follows:

(1) Each participant receives, through a mobile instant messaging app, a set of 18 illustrated cards containing the name and description of food additives (one for each card) (Figure 6).
(2) Participants must, in groups of two, roam the streets' markets in search of products for sale containing the food additives depicted in the set of cards.
(3) Upon the finding of such products, participants should send, through a dedicated channel in the instant messaging app, a picture of the product's barcode or label, along with a text containing the name of the product and the additive it contains.
(4) The game session lasts for 60 minutes.
(5) For every product/additive sent, players are awarded 1 point. Products sent for the first time are worth 2 points.
(6) The team with most points win.

Results and analysis

During that sixty-minute session, 125 valid submissions have identified a total of 103 unique products containing additives. Participants have found samples for 15 of the 18 food additives suggested by the cards. Artificial food dyes were the most popular type of additive, being found in 87 of the products submitted (approximately 84%). The distribution of scans, number of products, number of additives, and points by team is illustrated in Figure 7.

During the round of discussions with participants, which followed the testing session, some important points have arisen. The students commented on the fact they had not been priory exposed to any information regarding artificial food additives, and were not aware of the danger they could cause to their health. The professionals – who already had access to a great deal of information on that topic – commented, during after-test discussions, that they became even more concerned about the huge number of artificial additives in use by the food industry today. A few general observations were made in terms of the behavior change in terms of players' healthier eating choices the game could potentially entice. All the students participating in the test commented on that their simple awareness of the presence of so many different artificial food additives in products they often consume would make a difference in their future food choices, eventually changing their patterns of food consumption. The professionals said the test reinforced their concern on the current excessive addition of artificial additives to most food products commercially available, and commented on their fear of diseases their children might have in the future, as a result of this. We are currently organizing a second round of discussions with the same test participants to confirm if their participation in the initial test has in fact altered their dietary choices and food consumer behavior in some way.

From the data gathered during the testing session and from the following discussion among participants, several observations were also made regarding both the game's ability to sustain the players' interest and its efficiency in facilitating the building of the database. First, it became clear that a way of associating a product to several additives at once – instead of sending separate submissions – would help populating the database faster *and* increase player's satisfaction. Second, allowing players to submit products to classes of additives (e.g.: preservatives, dyes) instead of limiting them to specific ones (e.g.: Sunset Yellow FCF, E110) would increase the number of submissions and cover products who do not specify individual additives. Third, limiting the number of cards could improve the quality of submissions, making players focus on the task and encouraging the submission of less common additives. Fourth, attributing different number of points to different additives could have a similar effect in encouraging players to submit a wider diversity of additives. Fifth, allowing players to follow, in real time, the performance of other players could motivate them further, possibly being more engaging than

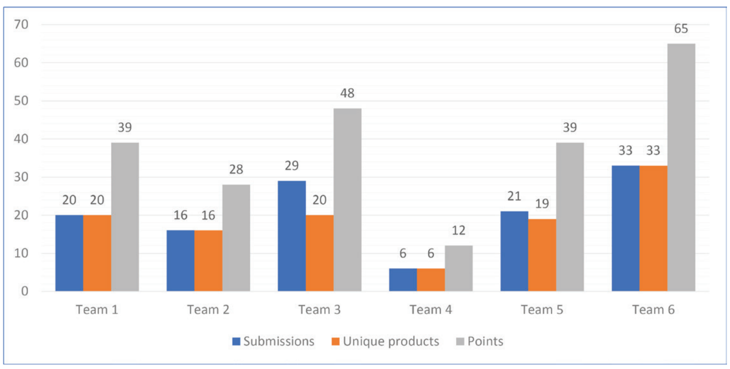

Figure 7. Submissions, unique products, and points awarded for each team.

merely displaying rankings and scoreboards. Finally, a time-based game mode should be considered, as the length of the session (60 minutes) was considered excessive by multiple testers.

Redesign and future development

All those experiment findings and testing results were used as guidance for our following design decisions. Initially, we decided that – although the project is being devised as a mobile application – it should have the "look and feel" of a game. All images and navigation elements should be redesigned to look less like menus and graphic elements usually found in apps, and more like playful, funny, game-like elements. The collection of data regarding the presence of artificial additives in food items should be easy and fun: users of Dyet should see it not as a boring and repetitive task, but as a playful, gamified activity, in which they may become fully engaged as game participants. We believe that – through the application of gamification techniques – the activities of sensing, collecting, retrieving and sharing information on artificial food additives may become almost transparent to the user. Since our target audience includes not only health-conscious consumers but also casual game players, we view such a gamification approach as a core element. By fostering users to be totally immersed in accomplishing the game's missions and highly engaged in their search for products towards obtaining premium cards, higher scores and game levels, we believe that not only those users who are aware of the risks posed by artificial food additives, but also those gamers who are not necessarily deeply interested in this specific theme, will happily perform all those phases, equally perceiving them as a series of dynamic and fun activities.

For this purpose – based on field research and mood board studies devised by the design team – we are currently developing a playful, compelling, colorful and dynamic game, with visual appealing elements and challenging missions. As such, our revised game structure states that missions should not be the only mechanism for rewards, allowing the "quick-scan" feature to compensate the player – albeit less that missions – as well. Additionally, the mission goals should not be restricted to the search of just a single ingredient, which grants the player the opportunity to identify food with a potentially increased hazardous composition through the combination of specific artificial food additives – for a greater in-game reward. To help increase the productivity of the gaming experience, our redesign also allows undertaking missions simultaneously – triggering a chain of rewards, but with capacity restrictions – and some of the missions can be performed with a group of friends, not only highlighting the potential for social engagement, but also stimulating a strategic approach as to which missions to prioritize at a given time. Another variation introduced was the creation of time-based missions, which invite the players to engage on "gold rushes", therefore supporting a deliberate change in pace.

As for its new visual identity, after devising several layouts with differing graphic approaches, we have decided for the idea of connecting the user to the ambience of grocery stores in Brazil, which advertise their special offers through bright and colorful hand painted signage along their stores, as well as on printed brochures, which are freely distributed inside the shops and as newspaper's booklets (Figure 8).

Figure 8. Brazilian grocery stores' signage: hand painted boards and printed advertisements.

Therefore, we are now devising a new visual language, totally based on the visual elements, typographic styles and use of colors of Brazilian grocery stores' signage. New examples of mission cards, rewarding cards and screen layouts are being designed, based on different combinations of those graphic elements. We have decided that not only the images, scoreboards and screen design, but also the navigation of the Dyet mobile application should be perceived as a game. As much as possible, traditional "app-like" navigation elements are being replaced by original "game-like" ones. These graphic elements are being redesigned to also reflect the ambience, visual language and identity of grocery stores in Brazil (Figure 9).

We are also aware of the importance of sound as a component in the design process, as part of the identity and expression of a product (Ferranti and Spitz, 2017). Sound can improve the interaction between users and products, services and environments (Ferranti, 2018). With the help of sound interface designers who are members of our team, we are currently exploring and devising auditory resources for Dyet, in order to give users of a more multi-sensorial gamified experience.

In terms of the project's future development, our goal is to test with different groups of potential users all those new ideas and features suggested. Designers and programmers of our team are working together to update the user journey's workflow and devise a Minimum Viable Product (MVP)

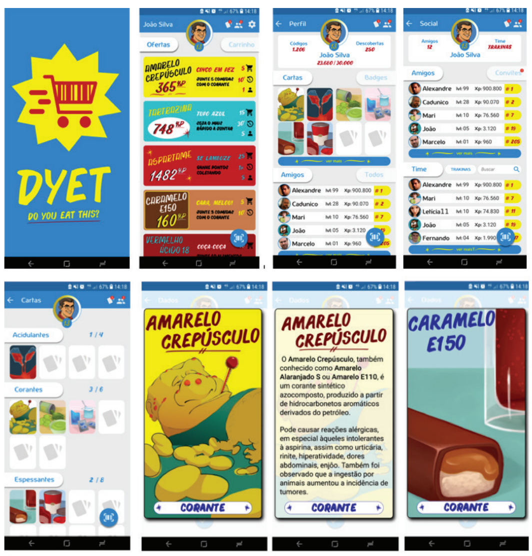

Figure 9. Examples of new mission cards and screen layouts.

to implement all the new proposals regarding its interface design and navigation, points progression system and other features and elements. By focusing on key aspects of the experience – such as mission selection, product scanning, database data entry and rewards – we should deploy a test-ready prototype that allows a manageable scalability and overall balanced, "non-gimmicky", gaming experience, which will enable us to get valuable feedback on the overall "look and feel" of the use of the application.

Concluding remarks

The concept of "open observatories" (Spitz, 2010) – coined by Roger Malina almost a decade ago – shed light on the importance of promoting a broader dissemination of methods and knowledge for micro science, intimate science, people's science and crowdsourcing. In his view, scientific knowledge is not culturally appropriated, and these observatories could meaningfully alter the way people deal with science, and make a substantial contribution to the development of a more sustainable society. In his manifesto "Intimate Science and Hard Humanities" Malina calls attention to the need to expand and disseminate scientific knowledge – which is still confined to "guarded monasteries" – and make science popular, intimate, meaningful and accessible to all (Malina, 2009).

The "common good" will only be brought about by people acting jointly and in common to achieve it (Quéau, 1999). The transformation of our society's mode of production – from industrial to informational – and the rise of open source technologies and peer-to-peer production have given place to new scenarios of technological and social innovation, demanding new creative approaches in terms of design processes, strategies and methods (Pereira Junior *et al.*, 2016).

In the view of Weiser, "there is more information available at our fingertips during a walk in the woods than in any computer system, yet people find a walk among trees relaxing and computers frustrating" (Weiser, 1991, p. 104). Today, however, younger generations find the use of mobile computing technologies easy and friendly, as they allow them to freely explore, connect, share and participate in all domains of life, giving them the choice to be everywhere, with everybody, at any time.

We firmly believe – based on literature review on similar projects' results, as well as on our own preliminary findings – that gamification processes can indeed engage voluntary participation in initiatives aimed at citizenship and the collection of diverse data. Adequate use of gamification techniques can turn complex and sophisticated tasks – such as in the case of several citizen science projects – into playful activities.

With Dyet, we hope to bring wider audiences closer to complex subjects such as dietary restrictions and health risks of food additives – in a fun, meaningful, intimate, and informative way.

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