

CHEMISTRY 2.0: BUILDING AND DISSEMINATING CHEMISTRY THROUGH STUDENTS-GENERATED WEB 2.0 CONTENT

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ABSTRACT—This paper analyses a project to enhance and develop Chemistry communication skills. A design-based research focused on 32 pre-university students, organized in three rounds, that developed resources using digital tools for different audience targets. Contrarily to initial assumptions, the subjects did not show signs of “chemophobia” or digital expertise. Random groups, *cadavres exquis* and group discussions helped to identify and to build more relevant, grounded and complex social contexts. When subjects have positive feelings about Chemistry and are not aware of the possible negative meanings of the Chemistry lexicon in society, it is necessary to stimulate a cognitive reframe and attitudinal awareness so that they can communicate Chemistry. Implications include the acknowledgment of the relevance of summer school projects that address socio-scientific issues to bridge conceptual knowledge and contextual significance.

Keywords: Public image of Chemistry; students-generated content; science communication.

1. INTRODUCTION

Scientists always communicated among themselves in networks. As science became more visible and science careers less attractive, science education and communication also became more urgent. This urgency is especially strong in Chemistry because of two main reasons: first of all, Chemistry is associated with a pejorative image that seems to go back to Alchemy and First World War. Second, it is a highly hermeneutic science: its three complementary dimensions (macro, submicro and symbolic) makes it hard to be understood by laymen. However, nowadays, one can expect that average students have, at least, some understanding of this science, but how well can they communicate their knowledge to others through web 2.0 tools? This article is structured as follows: we start by outlining the public image of Chemistry, the main concepts and assumptions on Web 2.0. Then the methodological design is exposed and main results are presented and discussed. We finish with important insights regarding the use of Web 2.0 in science communication projects.

2. RELATED WORK

2.1. The public image of Chemistry: brief history and challenges

Some authors suggest that a large number of people have a negative image of Chemistry. We are all too accustomed to the stereotype of chemists as “nerds” in white coats “ (...) not young, often bald, strictly male, (...) working on mysterious things, conducting projects which sometimes help save the world, sometimes harm our natural environment. ” (Luraschi, Rezzonico, and Pellegrini, 2012, p. 820). Chemistry is, often, associated with potentially hazardous substances, chemical war and environmental pollution (Francl, 2013). This is symptomatic of what Laszlo (2006) refers to as “chemophobia” – “the notion that ‘chemical’ is synonymous with toxic and unnatural” (Francl, 2013, p. 439), a prejudice that might have had its origin in Alchemy (Royal Society of Chemistry, 2004). The negativity surrounding Chemistry arose during the First World War, frequently mentioned to as “Chemist’s War”, when the use of explosives and poison gas contributed to an awful turning point in

society (Freemantle, 2012). During the 20th century, other controversial issues followed, causing lasting damage to the reputation of Chemistry, such as antibiotics, the effects of which persist nowadays (Royal Society of Chemistry, 2004). We are convinced that part of the solution to the problem can be achieved through good practices of science communication.

2.2. Participatory culture and new tools in Web 2.0 Age

Web 2.0 work as a medium for social learning allowing for participatory culture, this is, "... culture with relatively low barriers to artistic expression and civic engagement, strong support for creating and sharing one's creations, and some type of informal mentorship whereby what is known by the most experienced is passed along to novices" (Jenkins et al., 2006, p. 3).

Web 2.0 represents a shift to Internet users, from consumers to creators of content, fading out the boundaries that separate the creator from the user. Bruns (2006) has coined the term "produsage", a portmanteau of "production" and "usage", describing individuals who not only produce material but also use material created by others. According to Lee (2011) this new role of content producers has also resulted in the coining of another new term: "user-generated content". Likewise, knowledge creation through user-generated content is also being incorporated into education, giving rise to the idea of "student-generated content". The engagement in Web 2.0 environments is to be able to "provide more avenues for self-representation, expression or reflection and more organized forms of collaboration and knowledge building. Re-generation of content through remixing and repurposing, as well as networking and group-interaction are common activities" (Conole & Alevizou, 2010, p.12). Collaboration is a great tool that helps with decision making and effective strategies creation: "technology's role as a catalyst for student collaboration and therefore a medium for higher order thinking" (Cicconi, 2014, p. 61).

3. METHODS

A design-based research (DBR) was used in this investigation (Anderson & Shattuck, 2012).

3.1. Context and participants

Among the projects promoted by University of Porto, Universidade Júnior (began in 2005) is one of the projects with high social impact. Every summer holidays, each school opens its doors to young students from 5th to 11th grade, involving more than 5000 students and 350 monitors.

In 2014, we prepared a project named "Building and disseminating Chemistry 2.0" aiming the enhancement and development of Chemistry communication skills and the dissemination of Chemistry, using digital tools in the context of web 2.0, according to different audience segments. This project was targeted at students from 9th to 11th grades – pre-university students from all Portugal regions. The project had two editions: the first was held in 2014, for two weeks (round 1 and round 2) and the second edition was in 2015, during one week (round 3). The number of participants in each edition was: (i) round 1 with 7 participants; (ii) round 2 with 13 participants and (iii) round 3 with 6 participants. In each week, the participants were guided by two monitors, both PhD students: an expert in Chemistry education (A), and another in Communication and Digital Media in education. The project designers were experts in Chemistry education, Social Psychology and Digital Media. The team held several in-person meetings; talked on the telephone when necessary and exchanged e-mails daily. The planning and the materials were daily reviewed by the designers and were returned with reformulations, when necessary.

3.2. Design and procedure

The activities were organized for each day. On each of the days, the students were to use a web 2.0 tool to communicate - from their specific perspective - a theme about Chemistry.

Day 1: To randomly form the workgroups has several advantages and disadvantages (Bacon, Stewart, & Anderson, 2001), but we chose to use this method because we wanted to replicate the labour world contingencies. A second group selection method is to allow students to self-select their

group and then study in depth different Chemistry topics that they would later present to the larger group. Then, the small workgroups were reorganized, in accordance with the interests expressed for the themes, and would remain that way for the rest of the week.

The new groups would be responsible for organizing a general project about chemistry communication aiming to apply to funding, creating for that purpose an e-book (*Storyjumper*), where the planning for the week would be presented, including each web 2.0 feature and associated Chemistry theme to be published online (<http://www.cdg20.wordpress.com>).

Day 2: Groups would brainstorm about the video as a tool (*Animoto* was replaced by *iMovie*) for communicating science, prepare a video pitch taking into account the chosen theme and the target audience, presenting to the large group the results of their work and reflecting about it.

Day 3: Participants were supposed to explore comics (*Toondo*), stressing its significance and efficacy as a Chemistry dissemination tool. In the round 3, this web 2.0 tool was not used and, instead of it, a new type of resource was introduced: podcast (*Audacity*).

Day 4: participants were asked to devote themselves to the making of the animated cartoon (*GoAnimate*), each one commenting everyone else's work online. By the end of the day they would start creating the game (*Sloder*).

Day 5: Participants should use the morning of day five to finish the game and to evaluate it with their peers. In the afternoon they evaluated all the activities carried out.

Data gathered during the activities include field notes and meeting reports, emails, recordings and photographs, digital artefacts generated by the participants, self-report questionnaires and open, free association questions.

4. RESULTS

Keeping in mind that the participants chose to participate in the program, one expected that they had positive attitudes towards chemistry. This assumption was sustained by informal conversations between monitors and students as well as by the global results to a questionnaire on attitudes towards Physics and Chemistry (Neto, Candeias, Rebelo, Varelas, & Diniz, 2013). These data are not analysed in detail in this paper, but it is important to stress at least the results on the item "I like to study Physics and Chemistry" assess in a scale ranging from 1 (I completely disagree) to 4 (I completely agree), where the mean values are clearly above the middle point (round 1 and round 2: median = 3; round 3: median = 2.5).

Students were asked about what they associate to Chemistry and a content analysis of the answers (before and after the intervention) was conducted by two of the authors. After an exploratory analysis a set of categories was defined according to a: (i) cognitive dimension and (ii) an affective dimension. The cognitive dimension included values (e.g., learning, work); theoretical concepts (e.g., atoms, molecules); words associated with the experimental/laboratorial work (e.g., reactions, chemical reagents) associated with chemistry; objects (e.g., Bunsen burner); and contexts (e.g., laboratory). None of these categories *per se* are necessarily connected with positive or negative feelings. The affective dimension includes positive (e.g., fun, interesting) and negative (e.g., difficult) words. The authors essayed the coding in about 20% of the corpus and, only after achieving a high consensus, they proceeded to code the rest of the material.

Participants associated Chemistry with laboratory (e.g., reactions and experiences), with concepts such as atoms or Periodic Table and with values such as learning and the contexts such as laboratory, industries and classes. The main difference is the new category that emerged in the answers of the participants after the intervention took place: social and environmental visibility include words such as pollution, greenhouse effect or medicines. It should be noted that participants mentioned objects usually associated with the laboratory work (e.g., lab coats, gloves).

Considering all rounds of activities, we tried to find out if there was a connection between the students' choices of the Chemistry themes, target audiences and the typologies of the designed tools (e-book, video, comic strips, animation, games and podcast) (see Table 1). During round 1 the students struggled to identify their target audience and most of them couldn't face the challenge or

did it in an incipient way. The resources developed during the week were mainly of an informative and transmissive nature, without a social, environmental or technological context. The comic strips designed had some humour in it but, on the whole, showed lack of strong scientific content and presented a negative and alarmist image of Chemistry. The themes they chose to explore were independent of the tool they were designing or the target audience, except when designing the games. The games were built as quizzes and the groups chose to address general topics of Chemistry and target it to students from primary and secondary education. During round 2 the students continuously changed the themes in accordance with the tools they were designing. Nevertheless, their most frequent choices covered social impact themes such as chemical pollution, acid rain and doping. Since it had been difficult for the students to choose their target audience during round 1, this time the target audience for the first tool designed, the e-book, was decided by drawing lots for each group. This option seems to have resulted in more originality and initiative from the students. It should be noted that there was a tendency to link the tool “video” to a young/adult audience and the tool “animation” to a young/child audience.

The tool “comics” was linked to both audiences, children and adults. We observed an excessive definition of the target audience, almost like a caricature, which denotes difficulties understanding the common denominators that justify a careful choice of the communication strategies. Just like in the first week, during round 2 the tools designed by the students lacked organized scientific content, nevertheless there was a change in the nature of the message about Chemistry that was conveyed, which was not as negative as before and stressed the importance of Chemistry to our quality of life.

Table 1: Groups, themes, context and audiences

	Round 1	Round 2	Round 3
Groups	Three groups	Five groups, with the students being allowed to switch groups	One group on the first day and two groups thereafter
Chemistry themes	Superficial handling of the themes throughout the week (except for the games)	Superficial handling of the themes and wide thematic diversity, in line with the identification of social and environmental issues related to Chemistry.	Good handling of the chemistry topics connected - Acid rains (e-book) - SMOG (video, animation and podcast) - Water contamination (leaching) due to residues of mineral extraction
Social context	Identified but insufficiently described	Identified but superficially described	Adequate description: - Countryside (group 1) - Urban areas (group 2)
Audience	Unidentified or insufficiently characterized	Clearly identified and varied, sometimes excessively characterized	Clear and balanced identification and handling of the target

During round 3, on day one, students worked together in a single group, as referred before. They explored the acid rain theme. On day 2, as they were assigned to two different groups, students identified and chose other themes, namely, SMOG and water contamination (leaching) which were held constant throughout the week. The themes were developed in a deeper or lighter way according to the target audience. On day 2, the students produced e-books, both targeted to an elder audience - which wasn't easy due to the infantilized models of the software. SMOG and leaching were explored throughout the week, with the tool “video” targeted to young adults with academic degrees; “animations” to young students; and the “podcast” targeted to a scientific audience. Throughout the round of activities, students were able to use the Internet intentionally and systematically to publicize and to learn more about their chosen themes. We were hoping that the support offered and the challenges posed by the monitors and by the peers would favour the development of critical skills about digital literacy.

In round 3 a more critical approach was reached, since students organized a debate to get funding for their projects. Factual and socially relevant data was used, both for the mineral extraction problem as for the SMOG problem. Students fed the discussion and grounded their ideas with actual statistics on public health consequences, events and economic viability for an hour-long debate.

5. DISCUSSION

The cycle of activities was fed with a cross-disciplinary metaphor (Broman & Parchmann, 2014). Students would explore several contexts influenced by Chemistry, where they could play important roles, not only in the field of research or education but also in the field of Chemistry dissemination. This target may have been largely reached through the enlargement and increasing complexity of the domains and social contexts directly or indirectly influenced by Chemistry. Nevertheless, it would be desirable that, in future editions, less classical and less socially visible roles might be stimulated for the chemists, through the introduction of especially focused moments of reflection rather than through new activities. The expression user-producer, although questionable, identifies web 2.0 participative character. In a way, we expected that the students would understand the significant potential of the internet and, in that way, the daily projects (games, animations, videos, e-books, comic strips) would be published in a common blog which was open to their peers' comments. In reality, the students created their tools but they also used the tools created by their colleagues, whether as part of the small group or as part of the large group, thus simulating a small professional community. This idea is very much in tune with the idea previously expressed by Cicconi (2014).

Several circumstances contributed to the fact that throughout the weeks the use of the digital tools was highlighted. We acknowledge the need to widen the mapping of webpages suitable for the academic level of the users, which might be referred to during the group work, as well as the need to establish more effective search criteria. Exploring digital tools as a producer was a new perspective to the students (Lee, 2011). As we anticipated, by making the students' completed projects visible, the blog worked as public recognition (Alvermann & Hutchins, 2012), but we could have had larger audiences including students' parents and peers.

Participants in the study did not show signs of chemophobia, contrarily to literature (e.g., Francl, 2013). Instead, they valued and showed an interest for this area of knowledge. Feelings such as fear, anxiety, aversion, dislike, etc. are absent of the lexicon of the students. Also, for them it is not obvious that ordinary people might feel afraid or threatened or even hate Chemistry. The cognitive lexicon that they associated to Chemistry, such as laboratory, atoms, reactions, seems to be emotionally uncharged. Thus, they built their digital resources using this vocabulary and characters such as scientists and teachers, in scenarios such as laboratory and schools, ignoring that these symbols could trigger negative feelings in audience, despite the content of the message.

We should not stick to an emotional approach of the attitudes but also focus on the network of symbols, images and concepts that are the "bones" of the representation of Chemistry. This implies a cognitive reframe of the Chemistry lexicon, in such a way that what is neutral can be thought as eventually good or bad according to the target audience.

As we have realized, during the first week, that the identification of target audiences that look down at Chemistry and that relate it with problems was a difficult process, during the second week we suggested an exploration activity targeted at several diverse audiences. This activity was supposed to randomly establish psycho-sociological profiles, which would generate genuine *cadavres exquis*. Its main virtue was to activate divergent thinking processes which resulted in the re-centration of the issue under assessment, i.e., they helped to identify the socio cultural barriers that contribute to a distorted view of Chemistry. This strategy helped to identify/build grounded relevant and thick social scenarios. Besides being effective approaches in formal education (e.g., Onen & Ulusoy, 2014), socio-scientific issues also proved to be effective in informal settings.

6. CONCLUSIONS

In this article we presented a design-based research about a summer program on science communication through web 2.0, targeted at pre-university students in Universidade do Porto.

It is relevant to stress that the main assumptions (“chemophobia” and digital expertise) were not supported by the evidence gathered. Instead of an emotional approach to the students’ attitudes towards Chemistry, a cognitive reframe of meanings, images and concepts is more desirable.

The participants were interested about Chemistry and did not show “chemophobia” but still they associated Chemistry mainly with laboratory experiments and were not able to identify the social relevance of Chemistry. The process of scholarization of Chemistry is mainly directed towards the comprehension of chemical processes, which demands high abstraction levels. In fact, participants couldn’t identify the practical applications of Chemistry; and when they finally identified them, they couldn’t sort the adequate language to use according to the different target audiences. Conversely, they always used the terminology they learned at school. When the project became mature, students accomplished the intended goals mobilizing scientific savoir with rigor and simplicity. Being able to identify social repercussions and manifestations of Chemistry, as well as the professional opportunities, is critical if we wish that young students choose Chemistry courses. If projects like this one can help to bridge conceptual knowledge and contextual significance, systematic evaluation is required to adjust practices and enhance results.

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