

Ethanol in class and at home: guided inquiry-based learning

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Abstract

Guided inquiry-based learning centered on ethanol - used in the last eleven years in the first year of graduation in chemistry in a course created to stimulate critical thinking and integration in the university world - is presented and described. This ranges from the calculation of concentrations and the estimation of the rates of elimination and energies involved, to more controversial, as women and men characteristics, alcohol and diet paradoxes, societal issues, as binge drinking, and technological issues, as the working of the breathalyzer. All these issues are discussed using scientific results and show in practice how science develops and can be used for students' daily life.

Keywords: *first-year graduation; ethanol; chemistry and society; education in chemistry.*

1. Introduction

October and May (last year made with restrictions in some countries and the year 2020 canceled everywhere) have traditional student festivals all over the World. The present material was used in the last eleven years in a first-year course of “Tutorial in Chemistry” of the graduation in chemistry. The classes were also online and blended in recent years. The course “Tutorial em Química” has 6 ECTS (European Credit Transfer System) and was planned to stimulate critical thinking and to integrate students into the university. The students have two types of lessons: (i) theoretical-practice (TP) ones, with two hours a week along the semester with problems and discussion, and (ii) tutorial contact in small groups (typically four) with senior professors. The evaluation is made by mini-tests and oral presentations in the TP and the evaluation of the small groups is chosen by the tutors, ranging from writing and discussing articles to delivering presentations. In October, before the traditional students' festivity (“Latada”), we have a special class dubbed informally as “alcohol class” where these subjects are discussed, namely calculation of concentrations, rates of elimination, how it works the breathalyzer, drinking too fast, and social, even controversial issues, related with alcohol. It was used with 217 students since 2011.

In Portugal, and many other countries, the legal age to drink is 18 years, but in some countries, this age can be 21 years. Unfortunately, there are common problems with young people (see, e.g., Engs, 1990; Nyström, Peräsalo & Salaspuro, 1993; Miller & Weafer, 2009). Alcohol can be also a dangerous drug (Nutt, King & Philips, 2010). A larger number of fatalities in traffic are due to alcohol misconduct. Nevertheless, class and take-home discussions involving alcohol consumption (Nutt, King & Philips, 2010; Maio Clinic Staff, 2020) are in this work directed towards critical thinking and social issues that can be tackled using scientific methodologies.

In this paper, we present and describe guided inquiry-based learning (see, e.g. Gaddis & Schoffs et al. 2007) centered on ethanol to several matters, in particular to General Chemistry and Chemistry and Society. Due to the emotional involvement of the subject, this approach is expected to reinforce learning and provide issues that due to their nature originate meaningful knowledge that lasts for life (see, e.g, Chatterjee & Duraiappah, 2020). In the next section, we detail the methods and results and in the final section, we state the main conclusions.

2. Results

The first issue is the calculation of concentrations (see, e.g, O’Conner, 1981). Students are informed (some of them already know) about the alcoholic content of several beverages and asked to calculate the typical mass of ethanol of normal portions. Then, giving the body mass, the average volume of blood, and water content of a human body, the concentration of ethanol

in the blood it is asked to be calculated and compared with tables of intoxication effects. Students are also asked to be critical about the obtained values. Students that calculate the concentration based on the average blood volume are puzzled by the non-familiar result and are led to discover that the volume to use must be the body water content. But, why? The students can find explanations for this mystery and others (DeLorenzo, 2000; Ferriols-Pavico, 2002). They may find other ones as the relations between alcohol and fatigue (Dawson & Reid, 1997; Williamson & Feyer, 2000). Those findings can be legitimate or wrong. Can be myths, can be outside their level of application, are simply bad interpretations, or fake news. Care must be taken, of course, as one of the advantages of this dialogue is to stimulate critical thinking at the same time that matter is learned, not to reinforce wrong or mythical ideas. To reinforce the way Science works is of utmost importance. (see Table 1 for a list of issues and questions discussed).

Table 1. Subjects, problems, and exercises proposed to students.

What is made in class:
Calculation concentrations of alcohol of common drinks
Use alcohol concentration to interpret values in news and daily life
Discuss critically articles and myths about alcohol
Calculate rates of elimination and values of energy
Discuss alcohol in terms of time without driving and diet aspects
Discuss how it works the breathalyzer
See in practice how science works
What is referred to in class:
Intramolecular and intermolecular bonds and forces
Ethanol as a combustible and sanitizing agent
Historical, geographic, and interdisciplinary issues related with alcohol

We use real examples, and actual concentration calculations, to discuss the issue of binge drinking and social explanations and myths. It is now clear that the singer Amy Winehouse, unfortunately, died of alcohol misconduct (McLaughlin & Smith-Spark, 2011) and not from a “complex syndrome of alcohol abstinence” as previously disclosed (Parker-Pope, 2011). Based on the news data, students easily estimate the alcohol content and verify the results. This part of the guided inquiry is complemented with a discussion on the care that must be

taken with the news. Critical thinking is needed, plausible explanations must be confirmed with proofs.

Students are also asked to discuss if alcohol consumption can lead to overweight. Some of them already knew thin binge drinkers, others only know some fat drinkers, and they knew the labels (in Portugal we have the value of calories - in fact, kilocalories per gram - and an alert to the pregnant, the analysis of the label can also be made). Back to science, the calories of ethanol (around 7.1 kcal/g) are given for a certain portion. A calculation of this value can be made, and an explanation for alerting pregnant women can also be undertaken (if judge relevant). Alcohol is known to be highly caloric (the problem of feeling hot relating to ethanol being a vasodilator can be postponed) is known as the alcohol intake paradox (Jéquier, 1999) alcohol metabolism paradox (Shorey, 1999), or effect on nutrition paradox (Feinman, 2001; Aguiar, Da-Silva, & Boaventura, 2004). Most of the students see that heavy alcohol consumption can induce metabolic and behavioral changes. This can be more advanced and include the kinetics of drugs in the body (Calder, 1974) and biochemistry, saving lives with alcohol (Scala, 1973) and intoxication treatment (Breedlove, 1982). Of course, science is non-static and we had new treatments (Mégarbane, 2010). This can focus also on medicinal chemistry, the development of new medicines, and the nature of science. A trivial question is about drinking too fast (Ekelson, 1973). The warning appears naturally based on calculations.

Body fat percentage is sometimes considered the solution for the supposed mystery of the feminine part of humanity being more sensitive to ethanol than men (DeLorenzo, 2000; Ferriols-Pavico, 2002). Students are asked to be critical about this explanation. Some refer to the need for controlled studies, most of them pointing to volunteers with similar weights. The supposedly relevant psychological and sociological issues, as gender roles, and others appear naturally at this point. Again students are asked to be critical and scientific, not moral. Gender differences in alcohol consumption have already been studied (see, e.g., Engs, 1990; Nyström, Peräsalo & Salaspuro, 1993; Miller & Weafer, 2009) but the sexual behavior and chemistry can also be discussed, if judged relevant. A review (Jones, 2010) it was proposed the average value of 15 g/kg/h for moderate drinkers and 19 g/kg/h for binge drinkers. Those values can be used to discuss the transformation of variables, how it works in the scientific literature, the review system, what is a meta-analysis, chemical kinetics, and dimensional analyses, depending, of course, on the levels involved. The thermodynamics of drink driving (LaBianca, 1990; Thompson, 1997) are also referred to as average equilibrium constants based on Henry's law. In a more advanced course, critical analysis of statistical data (LaBianca, 1999), as well as analytical chemistry experimental determination of alcohol content (Lokken, 1975) and equipment used in the lab and daily life. Also, it is discussed the healthy effects of moderate drinking compared to the devastating effects of binge drinking

(Stockwell et al. 2016). This calls not to moralistic views but to a critical analysis of the literature and meta-analyses.

Of course, two hours of the class are not enough to touch profoundly most of these issues. The discussion of what originates "tears of wine" (Gugliotti & Silverstein, 2004). Ethanol can also be used for studying and teaching chemical bonding and intra- and intermolecular chemical bonds as usual. The question of 70% versus 96%, for example, may arrive, and this involves a lot of knowledge but in the end, experimental results show that the rates of evaporation are similar. So, why 70% is recommended? The historical and geographical issues can also be explored. In France, for example, alcohol in school was only prohibited only in 1956. Before that, wine is granted to all students at meals. Moreover, it is usual until recently to think of alcohol as a powerful substance. It was provided not also to students but also to workers. The working journey can include an amount of wine (in some countries of beer). How did this change? This is an inquiry that can also be followed depending on the degree of interdisciplinary that can be intended in the project. There are connections to history, geography, and others, it depends on the Country. In Portugal, both guided inquiry and interdisciplinary work are encouraged and taken as normal learning hours. Ethanol as combustible can also be studied and discussed (Pietro, 2009). In fact, after calling attention to a common substance one can teach and discuss most of the subjects scientifically. Most of these subjects are explored in this class.

3. Conclusions

Ethanol can be used in a series of subjects, concentrations calculation, thermodynamics and chemical equilibrium, chemical kinetics, critical thinking, everyday chemistry, observation, and analyses of the literature. It can be used also in interdisciplinary projects involving biology, historical, geographic, and philosophical issues. This molecule and the material based on it is very familiar to the students, and during the inquiry, some ethical issues are raised, creating an emotional discussion and, hopefully, more permanent learning.

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