

CONTEXTUALIZATION OF ANALYTICAL CHEMISTRY CONCEPTS TO THE PHARMACEUTICAL COURSE

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ABSTRACT

The purpose of this study was to determine whether the contextualization of the professional applications of analytical chemistry in the theoretical and experimental activities of the course would increase their interest and long time retention of the subject. A more contextualized version of the subject was applied for four consecutive semesters and the results were observed by testing the knowledge retention of the same student group by the end of their undergraduate course. The contextualization was based on the experimental quantitative analysis of several pharmaceutical commercial products and the improvement on the theoretical background of these products, such as their biological importance, toxicity, occurrence, industrial preparation methods and usual quantitative assays applied in the quality control of these products.

KEY WORDS: analytical chemistry, contextualization, pharmaceutical education

RESUMEN

El objetivo de este estudio fue determinar si la contextualización de las aplicaciones profesionales de la química analítica en las actividades teóricas y experimentales del curso aumentaría su interés y su tiempo de retención de la materia. Una versión más contextualizada de la asignatura se ha aplicado durante cuatro semestres consecutivos y los resultados fueron observados por probar la retención de los conocimientos del mismo grupo de estudiantes al final de su curso de pregrado. La contextualización se basó en el análisis cuantitativo experimental de varios productos farmacéuticos comercial y la mejora de la base teórica de estos productos, tales como su importancia biológica, la toxicidad, incidencia, métodos de preparación industrial y habitual análisis cuantitativos aplicados en el control de la calidad de estos productos .

PALABRAS CLAVE: química analítica, la contextualización, Educación Farmacéutica

INTRODUCTION

Analytical chemistry has showed an enormous change in the last fifty years. From wet chemical procedures to highly skilled instrumental methodologies, pharmacists nowadays are required to be qualified in all these aspects (Jansson, Vessman, 1997; Brehm, Breen, Brown, 2006). Although the professional needs have increased the demand on the instrumental knowledge, the fundamental concepts applied in analytical chemistry, such as physical and inorganic chemistry, are still a required methodology as a learning and fixation tool (Woster, 2003; Harrold, 2004). Moreover, the technical knowledge acquired during the experimental part of this course (i.e. correct manipulation of the labware and equipments) is of extreme importance for the introduction of what the students will have to be skilled later on: the good manufacturing practices.

In most of the pharmaceutical courses in Brazil, analytical chemistry is presented during the first two years of the undergraduate term (Abreu, Costa, Assis, Iamamoto, 2006). By the time pharmacy students encounter the application of analytical chemistry in the quality control of drugs or in quantitative clinical assays, some of the basic important concepts may have been forgotten. It is therefore essential that pharmacy educators identify teaching and learning strategies that foster a true and lasting comprehension of the main theoretical physico-chemical and technical skills learnt (Souza, Barros, 2003; Santos, 2007; Abreu, Iamamoto, 2003). Moreover, the students should be able to connect these concepts to their professional daily role in the industry, in bioanalytical determinations and in the research and development of new drugs and formulations. One of the teaching techniques applied nowadays is the introduction of the importance of the studied subject in the daily routine of the student. This means the professional contextualization of the academic subject.

The purpose of this study was to determine whether the contextualization of the professional applications of analytical chemistry in the theoretical and experimental activities of the course would increase their interest and long time retention of the main concepts discussed. This study was performed in the Pharmaceutical course of the Pharmaceutical Sciences Department of the Universidade Federal de Pernambuco in the Northeast region of Brazil. This course was founded in 1903 and was submitted to great changes in the offered subjects and also in the field motivation itself from its beginning. Since the eighties the quantitative analysis discipline is a 90 h course, offered twice a year, having one third of the course as a theoretical subject and two

Table 1 - The modified analytical methodologies applied and the samples used in the experimental part of the Quantitative Analytical course.

Sample	Methodology
Calcium Gluconate 10% (intravenous solution used in parenteral nutrition)	Gravimetric analysis using ammonium oxalate as the precipitation agent Complexometric analysis using EDTA as the titulant solution Oxi-reduction indirect analysis using potassium permanganate to oxidize the oxalate acid after the formation of calcium oxalate
Mg(OH) ₂ commercial suspension (laxating agent) or MgSO ₄ (intravenous solution)	Titulometric analysis based on acid-base reaction Complexometric analysis using EDTA as the titulant solution
FeSO ₄ ·7H ₂ O (Used as an iron source)	Analysis of Fe ²⁺ gravimetrically, using NH ₄ OH as the precipitation agent Analysis of Fe ²⁺ by colorimetric assay, using orthophenantroline as the complexing agent Analysis of SO ₄ ²⁻ gravimetrically by using Ba ²⁺ as the precipitation agent Analysis of SO ₄ ²⁻ by turbidimetric analysis applying Ba ²⁺ as the particle former.
NaCl 0,9% (physiologic solution)	Titrimetric assay by titulometric precipitation using AgNO ₃ as the precipitation agent (Mohr analysis)
Phosphoric acid (used as a phosphate source)	Analysis by colorimetric assay, using molybdovanadate as the color former

thirds as experimental. Up to 2003 this course was associated with the chemical engineering program course. The students performed experimental analysis of powdered minerals and other industrial samples. Although the analytical concepts were emphasized, it was observed that

there was a great lack of interest in the discipline and its applications. In order to motivate the studentship to this subject in 2004 the contextualization of the quantitative analytical subject to the professional application was performed, both, theoretically and experimentally. Since then, the contextualized samples are pharmaceuticals commonly used by the professional pharmacists in a daily routine. The pharmaceutical samples comprise intravenous solutions commonly used in parenteral nutrition (such as calcium gluconate, potassium phosphate, magnesium chloride), iron and phosphate oral supplements and other pharmaceutical formulations containing counteranions (such as sulfate and chloride) that could be quantified using either wet chemical procedures (gravimetric and titrimetric) as well as instrumental ones (colorimetric and turbidimetric determinations). The theoretical concepts incorporated a more thorough description of the most used instrumental methods of analysis, but reinforcing the need of the sample preparation. This was performed by adapting statistics/chemometrics concepts to improve the quality control of the samples studied and also the methodology itself (Correia, Ferreira, 2007). The present work presents the evolution of the students interest and their subject retention that occurred since this modification.

METHODOLOGY

Some of the modified analytical methodologies are summarized in Table 1. The course was divided in three main topics: gravimetric, titrimetric and colorimetric quantitative analysis. Some samples were analysed using more than one methodology and the results were compared by the students. For instance, the quantitative analysis of calcium in samples of intravenous calcium gluconate solutions was performed by gravimetric essay and by two different titrimetric assays (complexation and oxi-reduction volumetries) (Kennedy, 1990). In the gravimetric topic the thermogravimetric analysis of calcium oxalate urinary calculi was also utilized to emphasize the importance of this quantitative methodology in the health sciences context (Correia, Ferreira, 2007). A statistical approach is applied to the analysis of the results emphasizing its importance in the reproducibility of the method. Some of the concepts used in the quality control of pharmaceutical materials are exposed and related to some experimental procedures performed by the students.

In order to verify the retention of the technical and theoretical information given during one semester, questionnaires were applied to students (n=15, which represents at least 50% of the original students) of the seventh semester of the course containing several questions related to the professional application of the subject. This evaluation was performed for six consecutively semesters, being the first two semesters the control group containing students prior to the

contextualization of the analytical concepts in the course. The questions did apply the subject studied in a generalized form asking for their use in situations other than those performed in the laboratory premisses. Some representative questions are presented in Table 2.

Table 2 – Some representative questions of the questionnaires applied in this study.

What simple methodology could you apply to quantitative analyse salbutamol sulphate?
Is it possible to determine quantitatively the antiacid content in a commercial suspension?
Eating an iron -rich diet and taking a multivitamin with iron may be a useful way to prevent iron deficiency anemia. Comment on the analytical methods used to quantify iron .
Silver sulfadiazine is a sulfa derivative topical antibacterial used primarily as a topical burn cream on second- and third-degree burns. Suggest a quantitative method to quantify the silver content in the cream.
Intravenous magnesium sulfate is indicated for immediate control of life-threatening convulsions in the treatment of severe toxemias (pre-eclampsia and eclampsia) of pregnancy and in the treatment of acute nephritis in children. There are several methods used to quantify sulfate and magnesium . Mention one method for each of these species.
One of the concerns of the industrial pharmacy is the water quality, specially its hardness. Describe the fundamental method used in the evaluation of the water hardness .
Thermogravimetry may be used to characterize and quantify pharmaceutical substances. Could you supply an example of this application?
The thermogravimetric method may be applied quantitatively to renal lithiasis?
Oral administration of inorganic phosphates produces a fall in serum calcium in patients with hypercalcaemia. Suggest a method for the quantification of high dose phosphate supplement containing sodium phosphate monobasic.
What is the importance of the statistical treatment in quantitative analytical procedures?

RESULTS AND DISCUSSION

Qualitative and quantitative results were extracted after the data analysis. First of all, by contextualizing the experimental procedures the students showed a far greater interest in the theoretical topics and did associate them easily to many applications in the pharmaceutical industry and hospital units, such as the parenteral nutrition unit, which they work in the last semester of the course as an internship program. The importance of statistics was also associated in the interpretation and reproducibility of the methodologies by the students. Figure 1 shows the percentage of correct responses given by the students compared to the correct answers given by the control group.

The analysis of the results presented in the graph depicted in Figure 1 shows that there was a

40-80% retention of the main theoretical and experimental concepts by the students at the end of the pharmaceutical course which represents a very good achievement compared to the control group which showed an average of 33% of correct answers. The increase in the correct answers percentage throughout the academic semesters also suggests that the contextualization process was more effective as it was being repeated by the educator itself. The successful application of the contextualized approach in the quantitative analysis motivates the amplification of this methodology to other branches of the pharmaceutical course.

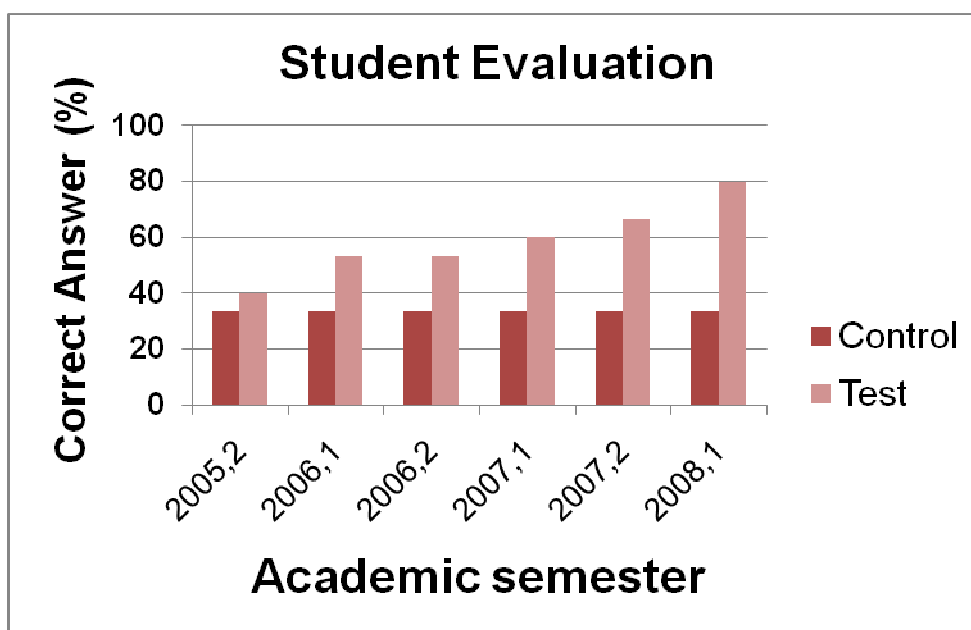


Figure 1 – A graphical representation of the student evaluation performed after the analytical chemistry contextualized concepts were applied for six semesters consecutively.

CONCLUSION

The degree to which students understood how the analytical chemistry course subject would apply to the professional environment showed a direct influence of how this subject was introduced. It was shown that the students retained a greater degree of background when the theoretical and experimental subjects were associated to the day-to-day act of the pharmaceutical professional.

REFERENCES

- Abreu D.G., Costa C.R., Assis M.D., Iamamoto Y.; (2006) “Uma Proposta para o ensino da química analítica qualitativa” *Quim. Nova*, 29(6) 1381-1386.

- Abreu D.G., Iamamoto Y.; (2003) “Relato de uma experiência pedagógica no ensino de química: formação profissional com responsabilidade ambiental”. *Quim. Nova*, 26(4) 582-584.
 - Brehm, B., Breen P., Brown B., et al. (2006) “An Interdisciplinary approach to introducing professionalism.” *Am. J. Pharm. Educ.* 70(4) Article 81.
 - Correia P.R.M., Ferreira M.M.C.; (2007) “Reconhecimento de padrões por Métodos não supervisionados: explorando procedimentos quimiométricos para o tratamento de dados analíticos”. *Quim. Nova*, (30)2 481-487.
 - Harrold, M. W. (2004) “Educational challenges facing basic science faculties”, *Am. J. Pharm. Educ.* 68(1).
 - Jansson, S.O., Vessman, (1997) “The Industrial Point of View: Competence Development in Pharmaceutical Industry” *J., Am. J. Pharm. Educ.*, **61**, 202.
 - Kennedy, J. H., (1990) “*Analytical Chemistry Practice*”. 2nd Ed. Saunders College Publishing, 1990.
 - Santos N.P.; (2007) “Passando da doutrina à prática: Ezequiel Corrêa dos santos e a farmácia nacional”. *Quim. Nova*, (30)4 1038-1045.
 - Souza A.M., Barros S.B.M.; (2003) “O Ensino em Farmácia; Pro-Posições” – 14(1) 40.
 - Woster, P. M.(2003) “Maintaining basic science content throughout the PharmD curriculum”. *Am. J. Pharm. Educ.* 67(3) Article 99.
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