
AC 2012-3493: AN INITIAL ANALYSIS OF STUDENT ENGAGEMENT WHILE LEARNING FOOD ANALYSIS BY MEANS OF A VIDEO GAME

Mr. Jose del Carmen Chin Vera

Prof. Aurelio Lopez-Malo, Universidad de las Amricas, Puebla

Aurelio Lopez-Malo is professor and Past Chair, Department of Chemical, Food, and Environmental Engineering, at Universidad de las Amricas, Puebla, in Mexico. He teaches food science and engineering-related courses. His research interests include emerging technologies for food processing, natural antimicrobials, and active learning

Dr. Enrique Palou, Universidad de las Amricas, Puebla

Enrique Palou is Director, Center for Science, Engineering, and Technology Education in the Department of Chemical, Food, and Environmental Engineering at Universidad de las Amricas, Puebla, in Mexico. He teaches engineering, food science, and education-related courses. His research interests include emerging technologies for food processing, creating effective learning environments, using tablet PCs, and associated technologies to enhance the development of 21st century expertise in engineering students, and building rigorous research capacity in science, engineering, and technology education.

An Initial Analysis of Food Engineering Student Engagement While Learning Food Analysis by Means of a Video Game

Abstract

The effects of playing the draft video game Food Analysis Simulator (FAS) by Food Engineering students of *Universidad de las Américas Puebla* (UDLAP) that attended the food analysis course and corresponding laboratory during Fall 2010 semester were investigated. Pre-post test students' results demonstrated a significant improvement in their knowledge after being exposed to the video game; there was a positive change in the students' scores from 7.2 ± 0.5 to 9.0 ± 0.5 . Our findings suggest that virtual laboratory FAS can be effective in achieving course learning goals, such as students being able to understand the principles behind analytical techniques, being able to use (in our case, using a simulation) the laboratory techniques common to basic and applied food chemistry and analysis, as well as being able to select the appropriate analytical technique when presented with a practical problem.

Introduction

Among the skills required for various science and engineering specialties related with food handling, transformation, preservation, processing, and storing are those associated with understanding and applying analytical techniques for determining food composition. These skills involve not only theoretical knowledge of the implicated techniques but also the ability to perform them in the laboratory as well as properly analyzing, interpreting, and evaluating the obtained results. In many cases, within the curriculum, laboratory sessions are included in order to cover these aspects. However, the hours spent in a semester by students in a food analysis laboratory are usually not sufficient to ensure that the intended skills are attained.

On the other hand, the use of digital games has grown markedly between youngsters, along with unlimited access to computers and many other computing-capable devices. Today computers and computing-capable devices are normal tools, and this has resulted in the production of accessible digital environments, whether at home, school, work and other different places. As a result, there is a generation who has grown up knowing the world with computers, and who cannot imagine working, playing, searching information, consulting, etc., without access to the tools provided by digital media¹. Current generations of students have extensive experience with computer and video games, which makes them different in their learning style preferences of previous generations¹⁻³.

Framework

UDLAP is a Mexican private institution of higher learning committed to first-class teaching, public service, research and learning in a wide range of academic disciplines including business administration, the physical and social sciences, engineering, humanities, and the arts. Since 1959, the Commission on Colleges of the Southern Association of Colleges and Schools (SACS) has accredited UDLAP in the United States. UDLAP's School of Engineering offers since 1970 a bachelor (*licenciatura*) program in food engineering, with the following goal: "To educate well informed, critical, creative and innovative professionals that are highly skilled in food science, engineering, and technology, but above all, aware of their great social responsibility to ensure a fair distribution of the benefits of globalization". Our Food Engineering program is approved internationally by the Institute of Food Technologists (IFT) and accredited by the *Consejo de Acreditación de la Enseñanza de la Ingeniería* (CACEI), which is the peer-accrediting agency of ABET in Mexico.

Course descriptions

The studied courses, Food Analysis and Laboratory of Food Analysis are a junior level 3 credit required course and its corresponding 1 credit required lab for the Food Engineering program at UDLAP. Approximately 10-12 students are enrolled in per semester. Food analysis (theory and lab) courses major goal is to help students think about the way a food analyst does. Thus, students are involved in understanding key subjects while achieving the following outcomes: be able to use the laboratory techniques common to basic and applied food chemistry and analysis, be able to select the appropriate analytical technique when presented with a practical problem, and understand the principles behind analytical techniques.

The fundamental concepts of the courses are, therefore, the chemical composition of food and its relation with available techniques for determination of different food components, the principles behind these techniques, and the application and interpretation of food analysis techniques and obtained results to determine food composition.

The IFT competencies related with food analysis can be summarized as (a graduate should):

- be able to use the laboratory techniques common to basic and applied food chemistry
- understand the principles behind analytical techniques associated with food
- be able to select the appropriate analytical technique when presented with a practical problem
- demonstrate practical proficiency on food analysis laboratory
- be able to apply and incorporate the principles of Food Science and Technology in practical, real-world situations and problems

Consequently the learning outcomes of the food analysis course and lab are as follows:

By completion of the Food Analysis course the student should

- understand the relevance of food analysis in the food industry, health and safety regulatory organizations and research
- remember and apply some mathematics and statistics to data obtained from food analysis and evaluate the accuracy of results
- understand the characteristics of sampling for food analysis as well as the handling, preparation and storage of food samples
- understand, explain and analyze the physical, chemical or biological principles of the analytical methods applied for food composition, identify and evaluate the limitations as well as the advantages of the different qualitative and quantitative techniques for determining moisture, ash, fat (lipids), protein, total sugars, crude fiber, dietary fiber, and some vitamins and minerals
- write, understand and explain by oral skills the novel techniques of analysis for specific food analysis applications of spectroscopy, chromatography (HPLC, GC) and biological assays among others
- understand, interpret, apply and assess the content of scientific publications related to the themes of this course

By completion of the Laboratory of Food Analysis course the student should

- execute different procedures in order to determine a determined component in foods
- compare the experimental result with the correspondent data from manufacturer or literature and explain differences if it would be necessary
- distinguish differences between the studied methods
- critique the different techniques applied during the lab session
- argue what method is the most adequate depending of the food type
- use and recognize the advantage of instrumental equipment for food analysis
- select a food, propose and apply the appropriate analyses to estimate its composition
- understand professional and ethical responsibilities

Because of the importance for students to recall and apply analytical techniques in the food analysis lab, a draft video game was developed in order for students to try (play) before going to the lab and test their hypothesis. The Food Analysis Simulator (FAS) was developed using a constructivist perspective, in which students are “learning while having fun”⁴. Constructivism theoretical perspective is the belief that knowledge is constructed not transmitted, and that learners play an active role in the learning process. Students can learn in a relaxed and fun environment without having the feeling of begin evaluated, and they can make mistakes and learn from them, using the feedback of the FAS immediately. The elements of constructivism included in this project are assessment of previous knowledge, flexible learning, creative thinking, and integration of knowledge and contextual learning^{5,6}. Today students could learn

more effectively if they had access to materials that take advantage of their abilities to interact with digital video game environments. A video game can be effectively adapted to include educationally oriented challenges^{4, 7, 8}.

Our progress so far has been to identify several common methods and techniques used in food analysis, like gravimetry, potentiometry, and titration in which the video game has been developed and identify common student preconceptions, misconceptions, and several theoretical concepts that are usually not fully understood in the theoretical class prior to put them into practice in the lab. The development of FAS intends to impact students learning cognitively, metacognitively, and affectively, in order to improve their academic performance while maintaining the cognitive load of the game according to course learning objectives^{9, 10, 11}. Schrader & McCreery¹² propose that students develop skills and expertise through the use of video games.

Research design

Population

Engineering students of UDLAP that attended the food analysis course and laboratory during fall 2010 as well as students who had already taken the course and the laboratory were our studied group. We designed six problems related to three of the most common techniques in food analysis: determination of protein content, ascorbic acid, and sodium content; which are related to gravimetric and volumetric methodologies, as well as the standard curve concept. These methodologies and related problems were selected from our previous experience demonstrating that the concepts behind, manipulation of the information, and interpretations of results have been difficult to understand and/or interpret by our students.

Assessment of previous knowledge and change in knowledge

Before begin allowed to use the FAS, students were asked to answer a pre-test in order to assess their previous knowledge. This pre-test consisted of 6 open-ended questions that were related to determination of protein content, ascorbic acid, and sodium content; which are related to gravimetric and volumetric methodologies, and the standard curve concept. Examples of the questions posted are:

1. You took 1 g of a solution containing 10% w/w of food X. Sample was diluted with water to the mark in a 100 ml volumetric flask. Then you took 10 ml for analysis and obtained a result of 0.500 mg of protein. Express the protein concentration as % in the sample.
2. Calculate the protein concentration (in %) from the following data: it is a colorimetric method with the following standard curve

$$\text{Abs} = 0.3466 (\text{mg protein}) + 0.0450$$

0.35 g of sample is dissolved and diluted to 250 ml, 10 ml were taken from this solution and then make it react to determine the absorbance, and the result was a 0.400 Abs.

After 2 weeks using the video game, the post-test included not only the same questions from the pre-test, but also new questions based on the expected knowledge and skills that the student should acquire after being exposed to the FAS. An example of questions included is the following:

1. You are responsible for food analysis lab within the company "*Pepin Juice the never-ending delight*" leader in the domestic market. One of the key to the success of the brand is maintaining a nutritionally attractive concentration of vitamin C. John Doe is the new manager of the company' laboratory analysis and he is required to determine the ascorbic acid content in the juice "Extra-Punch-2000" by a colorimetric method (measuring the absorbance) at 740 nm. After a while, the manager a little green because he cannot estimate the concentration, brings you the following data, aliquots of 5 ml of juice were taken, and to each sample 20 ml of Folin-Ciocalteu were added and diluted to 50 ml. The samples were allowed to stand for 30 min to fully develop the color and read the absorbance of each of the replicas in a spectrophotometer. What information is missing to John Doe to calculate the mg of ascorbic acid in the sample?

Technology

Actually the use of avatars in virtual worlds is a resource that allows the researcher to analyze the activities of the students to know what students are thinking and what they understand¹³. So evaluation can also be incorporated as and in-game activity¹⁴. To make use of this information the FAS was integrated to a database that keeps track of the student's activities, currently stores the ID of the player, date, start and end time of each session, materials and equipment used in this video game. A virtual laboratory was created building 3D objects using Maya[®] software and game engine Unity 3D[®] with in which the students were able to explore and to apply their prior knowledge and they can learn in a relaxed and fun environment without having the feeling of begin evaluated.

Data analysis

Conventional statistical analysis was made using SPSS for Windows, for comparison between the pre- and post-tests. Results are considered significant if $p < 0.05$.

Results and discussion

The FAS mimics UDLAP's Food Analysis Lab. Images of video game screens are shown in Figures 1 and 2.

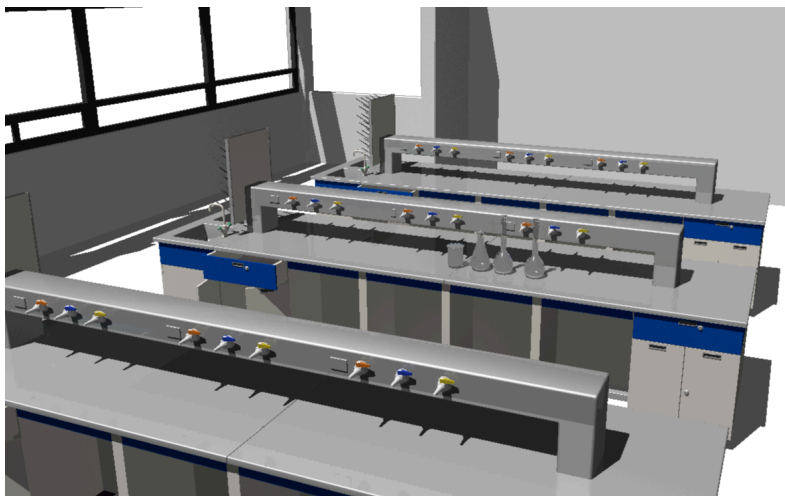


Figure 1. Screenshot of Food Analysis Simulator (FAS) video game.

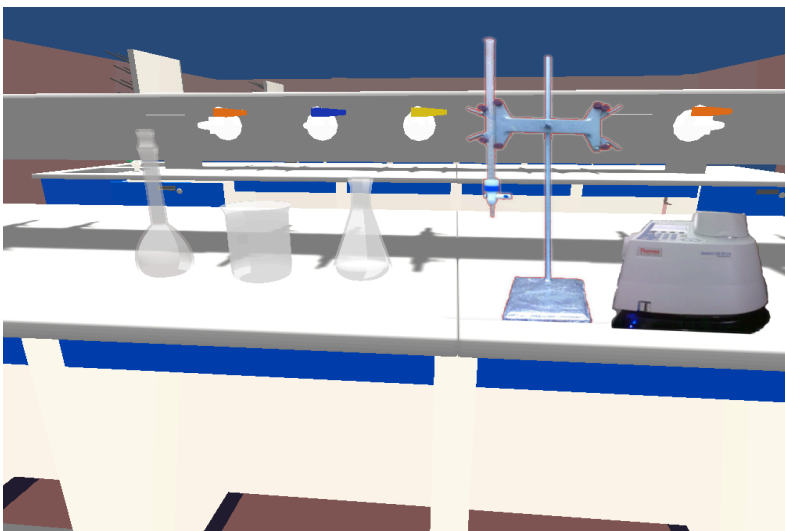


Figure 2. Screenshot of Food Analysis Simulator (FAS) video game.

Survey results indicate that students need more hours of practice to solve problems that are common in this type of food analysis and laboratory courses (Figure 3). In addition, 90% of students expressed interest in playing (and thus practicing) the draft video game. The first alpha version of the video game includes situations involved in protein content determination in foods, and takes into account many important aspects from the preparation of solutions to the calculations involved as well as interpretation of results.

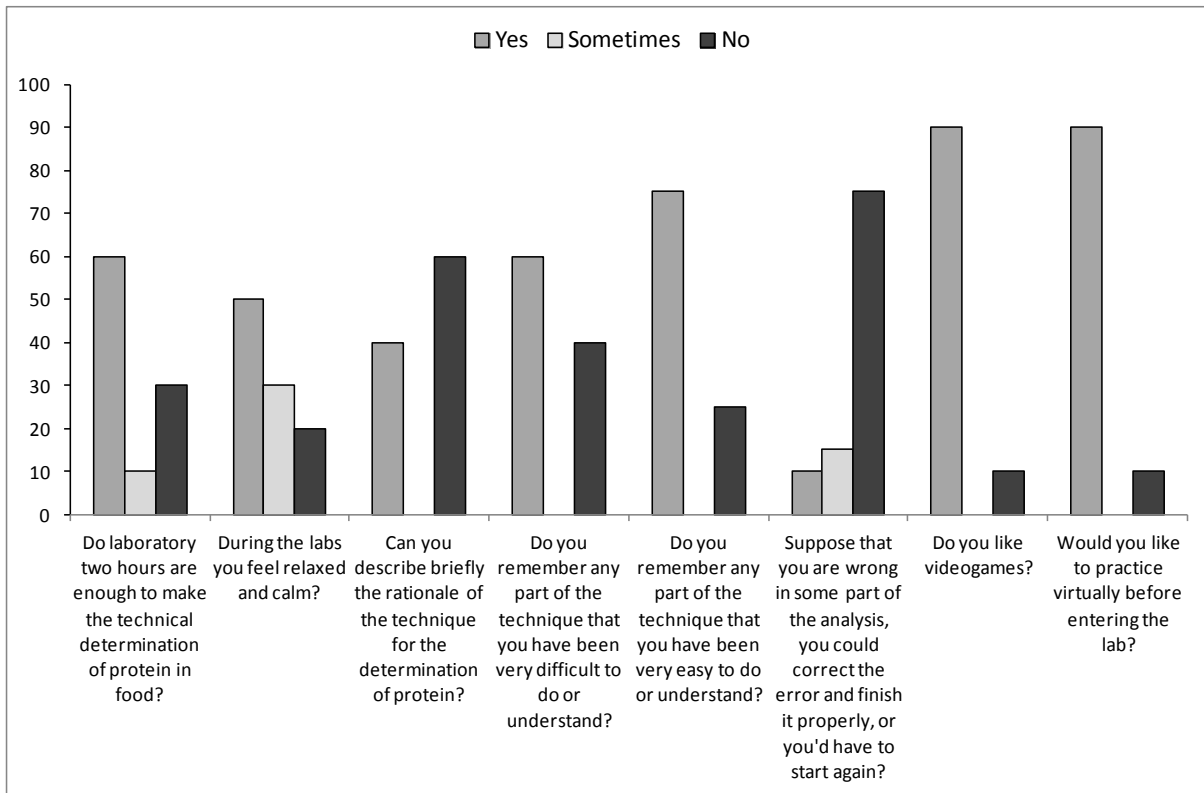


Figure 3. Survey results as percentage of student answers

Students were allowed to interact with the video game for two weeks (participating on average two hours per week). Then we applied the post-test (second set of food analysis problems) and results exhibited that conceptual understanding was better in student-players than in no-player's students; further, student ability to solve practical food analysis problems after playing was significantly ($p < 0.05$) improved. Students demonstrated a significant ($p < 0.05$) improvement in their knowledge as assessed by pre- and post-tests (Figure 4).

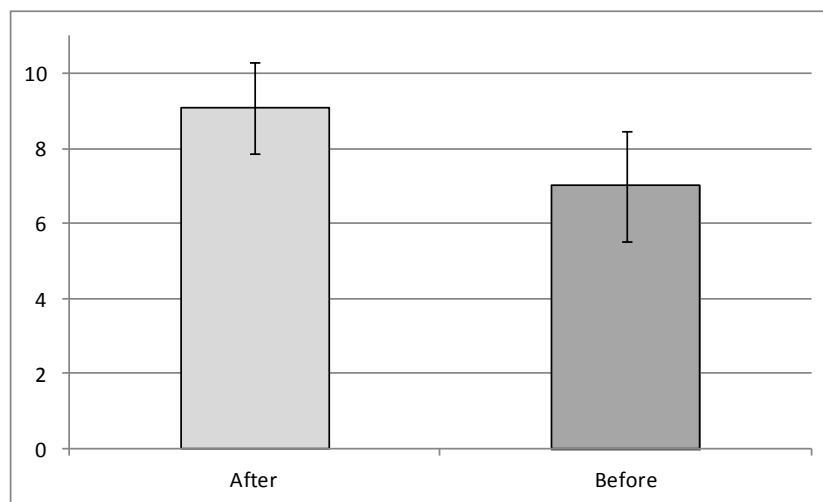


Figure 4. Students' mean scores (on a scale of 10) on the pre- (before) and post-tests (after).

Students effectively enhanced their knowledge about the principles of food analysis by means of playing the FAS. Simulation games and virtual worlds have been widely used as pedagogical aids to increase students' engagement over the past decade; the use of simulation games has been growing for teaching several courses^{4-6, 15, 16}.

The main goal of the FAS is that students can "perform" several analytical techniques applied to foods and have the "feeling" of being in a real laboratory, making their learning more attractive and less tedious for them. The perspective of the FAS is "first person" like many modern First Person Shooter games as Call of Duty 3. The interaction with the student is performed by pointing an object and make click on it, it's connected to a MySQL database in order to log each student activity, which can be used to assess the materials chosen by the students for laboratory work. The hardest part in the development of the FAS was to create the 3D models in order to build the virtual laboratory, including furniture, glassware, equipment, reactives, as well as programming to enable the player to interact with these elements.

The FAS can be adapted to various roles and scenarios, which will allow teachers to create different types of problems such as changing concentrations of solutions, different types of food samples (meat, bread, juice, etc.), change the volume of laboratory glassware, among others. The FAS could also be applied in industry to create specific problems and use them as one of the tests for candidates for a position within the company. The ability to add multiplayer mode (which we are testing nowadays) will allow the FAS to be more real. Since we utilized a Unity game engine, it is also feasible to port the FAS to smartphones, tablets and other mobile devices.

Final remarks

By using current technology to develop 3D games, it is possible to create virtual environments very similar to reality, allowing the student to perform a "virtual analysis" of food, as often as necessary, since in case of not obtaining the expected results, the simulator will provide the student with feedback immediately, so that he/she will practice his/her skills prior to perform analysis in the real laboratory and optimize his/her lab work time. On the other hand, by using FAS, educational institutions will optimize the actual costs of materials, reagents, measuring instruments, and laboratory equipment, since errors made at the real laboratory exercises, will be fewer and if they occur, students will be prepared to make necessary corrective actions due to their previous practice at the virtual lab. The FAS is still under development, but has exhibit that it is a fine learning tool that motivates students with regards to laboratory experimentation while improving their test results. However manual and other psychomotor skills can only be developed by working in a real laboratory.

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