FOOD SCIENCE FOR HIGH SCHOOL STUDENTS: A UNIVERSITY-HIGH SCHOOL COLLABORATIVE PROJECT

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Abstract

The Universidad Miguel Hernández of Elche (UMH) has recently launched a collaborative program among the University and High School centers called OSMOSIS in order to promote teaching innovation and to offer University infrastructure and equipment for high school advanced projects. The present work shows a case in which the Science Departments of the High School Jaime de Sant-Ángel form Redovan (Alicante, Spain), the AgroFood technology Department of UMH and the Didactic and Interactive Museum of Science Vega Baja (MUDIC) work on a Food Science STEM (science, technology, engineering and mathematics) project under the OSMOSIS program. The University prepared a proposal based on traditional bread-making involving a traditional local bakery from Redovan. The project was designed for 4th grade (15-16 years) students. The project combines knowledge on food science (microbiology and food chemistry), food engineering (equipment design: mixers and ovens), using 7 different flour types for bread-making, and running chemical and sensory analysis at the University laboratories. Results are further analysed and compared in order to establish relations among flour composition, and bread properties. Finally, students may present a report of the project in a science fair. The activity was organized in 5 blocks of activities: 1) A traditional baker from Redovan presents his experience and explains traditional bread-making procedures to the students, High School and University teachers, 2) Presentation of the working schedule to students and science teachers, 3) The students attend to the University: make bread and analyse bread samples, 4) Data is processed back at High School and jointly corrected by University and High School teachers, 5) The students present the project in a science fair. Although the present project was joined by High School science departments (physics, chemistry and biology), it can be connected to several disciplines: economics, history, geography, as it relates ancient and modern technologies as well as local traditions, whereas including new sources of cereals and pseudo-cereals introduced in the recent years in the marketplace. We present the project in detail as an example of interdisciplinary collaborative project among University and High School.

Keywords: STEM, food science, high-school, SME.

1 INTRODUCTION

Universities try to get increasingly closer to society, and one of the main target groups is that of High School students. Many activities such as science fairs, open days, contests, and others are usually offered by Universities to High Schools. Recently, the Universidad Miguel Hernández of Elche (UMH) has opened a call in order to establish long term collaborative projects among the University and individual High Schools interested in introducing their students to research and development experiences, as well as to connect them with real situations in need of innovative approaches. Coordinators of the projects have to be High School teachers that get in contact with a research group from the UMH demanding from them a research proposal for their students. Usually, such project proposals are part of their research or small projects to be run by University students. Research projects are re-designed to fit the academic level of High School students whereas trying to be still challenging for them. Students will benefit of the use of University facilities, activities specially designed for them and connected to their local society and high school courses. It is essential a good coordination among High School and University teachers in order to benefit from the synergies among them and still be able to challenge students. Involved High School teachers are motivated teachers trying to engage students’ participation by offering them innovative activities [1], and promote favourable attitudes towards science. It is in this sense that we could count with the participation of a
local small enterprise leaded by a pastry chef that has created a local business from an innovative approach to bakery and confectionery.

Experiences from the real world are complex and involve many disciplines, they maybe considered as STEM projects, involving science, technology, engineering and maths, as well as other disciplines. The project combines knowledge on food science (microbiology and food chemistry) and food engineering (equipment design: mixers and ovens). A food science based STEM project is proposed for encouraging science learning achievements of secondary students at their last year of high school (15-16 years). We present in this paper a STEM project involving a famous pastry chef, the High School of Redovan (HSR) and the AgroFood Technology Department from UMH. We detail their connections with topics of secondary education, those exploited in the present study, as well as those that may have been also connected with the project. The title of the project was “Bread-making as influenced by the type of flour”.

The aim of the present project is to present an experience of collaboration among High School and University through a food science project with the collaboration of a pastry chef. The experience connects traditional bread-making technology, a local innovative bakery -as an experience of entrepreneurship- and food science through the determination of the influence of seven different types of flour (whole wheat, bread wheat flour, all-purpose wheat flour, rye, whole spelta and non-cereals flours: quinoa and chia) on the physical and sensory characteristics of bread.

2 METHODOLOGY

Agents involved in the activity were students, High School teachers from the Science Departments of the High School Jaime de Sant-Ángel form Redovan (Alicante, Spain) (HSR), University faculty from the AgroFood technology Department of UMH and the Didactic and Interactive Museum of Science Vega Baja (MUDIC), and a traditional bakery and confectionery (El Crujiente, Redovan). All worked together on a food science STEM project under the OSMOSIS program.

This activity was carried out at the facilities of the High School of Redovan and the Escuela Politécnica Superior of Onhuela of the Universidad Miguel Hernández. Facilities used were: Laboratory of the University equipped with appropriate material (mixers, oven, calipers, weights…); students were provided with templates and markers for data collection, as well as safety equipment for chemical laboratories. Students were distributed in two main groups of 20 students; they worked in sub-groups of 2-3 people. Whereas the first 20 students run laboratory work, the second group visited MUDIC and vice versa.

2.1 Preliminary work on IES Redovan:

The present project involves two main activities at the HSR: the visit of a famous baker and confectioner (from El Crujiente, Redovan) on February 17th 2017. He explained to the students his experience as entrepreneur and his life adventure to become a recognized professional in his field, as well as the process of traditional and modern bread-making. The visit was prepared by the students, so they already had a list of questions on the topic.

The second activity was a visit of the UMH teachers involved in the project, on February 23rd, to explain the activities to be run at the University. The explanations of the confectioner served as a base for the project to be run. Laboratory instructions were provided at that time, so High School teachers could plan activities to introduce concepts to the students.

Since early March students run activities at HSR related to the project (introducing concepts such as proteins, yeasts, fermentation…). On March 10th 2017, students and high school teachers came to the University for the bread-making and analysis.

2.2 Work carried out at the University:

Students prepare bread with different types of flour (whole wheat, bread wheat flour, all-purpose wheat flour, rye, whole spelta and non-cereals flours: quinoa and chia) following seven formulations and determine the physical and sensory characteristics of bread. In order to fit the work on a 2 hour session, the practice will start from doughs already prepared and fermented in advance, that were allowed to temper before the session, so students prepare doughs but do not bake their own but the ones prepared in advance.
While baking and cooling the breads, students begin to prepare new doughs according to the proposed formulations. They were provided with raw materials (flour, water, salt and yeast). Once baking was finished bread loafs were allowed to cool down for about 10 minutes. Afterwards the following determinations were run:

Graphic register of the bread: loafs were cut in slices 2 cm thick. Slices were placed on a white background, and a graduated ruler was put on the slice (Figure 1). Pictures of the crumb were taken and then numbers of alveoli in a 5 cm² surface were counted. Alveoli were described: size, uniformity, and distribution. A table was prepared with the results for all types of bread according to the seven tested formulations.

Determination of loaf volume and density: The volume is determined by the seed displacement method. Briefly, in a graduated cylinder flax seeds are introduced to a known low volume, afterwards a piece of bread of 25 g is introduced and covered with more seeds until a certain volume, the occupied volume (V1) is recorded. The graduated cylinder is emptied and the flax seed is separated. The cylinder is filled with all the flax used (V2). The difference between the two volumes is the bread volume. The bulk density of the bread is determined and students fill a table with data of all types of bread.

Determination of the coefficient of elevation: it is obtained dividing the largest diameter of the bread (cross-section) by the height of the bread. Both measures are taken on a slice 2 cm thick. All loafs are cut and measured and the students filled a table with all values for each type of bread, afterwards they calculate the coefficient of elevation.

Determination of the percentage of crumb: a slice of bread is weighed, the crust removed and weighed. The percentage of crumb is then calculated.

Determination of the water holding capacity: 25 g of bread are covered with water, then the wet crumb is centrifuged and the expelled water removed. Wet bread is weighed again and the weigh difference allows the calculation of retained water. Afterwards a table was filled with the results of all types of bread.

Sensory determinations: recently cut slices of 1 cm thick were obtained. Students were given a brief introduction to sensory evaluation and then they evaluated the following attributes: color of crumb and crust, hardness of crumb and crust, crumb sweetness and texture of crust and crumb.

Questions to be answered by students: Once the doughs were prepared, baked and loafs had been evaluated, students checked the commercial denomination of the product according to National Regulations.

3 RESULTS

Forty students from 4th grade of ESO (Educación Secundaria Obligatoria) were engaged in the project, all of them were enrolled in Biology, Physics and Chemistry courses at High School, a total of 4 teachers from the HSR were involved in the project. The confectionery El Crujiente was involved in the project. Three faculty members and one technician from the University were involved as well. Table 1 presents potential connections of the activities of the project with disciplines taught at high school level that were or could be connected with the present project.

3.1 Contact with a professional confectioner

Given that pastry chef José Manuel Marcos Candela from “El Crujiente Petits Plaisirs” is one of the most famous confectioners from Spain with his business in Redovan, he was asked to join the project. He visited the HSR and met with students and teachers for about 3 hours in order to present his experience and also to explain the process of traditional and modern bread-making. Students had already prepared, individually, questions to the chef in order to learn about the bread-making process.

With this activity several concepts may be introduced to students such as: communication with experts, non-conventional learning methods, self-motivation and experience of success, among other. Students from economic courses from HSR also attended this presentation as it is closely related with their courses, social economy and small-medium-enterprises experience.
Table 1. Main activities of the project and potential connections with disciplines of high school courses.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Physics</th>
<th>Chemistry</th>
<th>Biology</th>
<th>Maths</th>
<th>Engineering</th>
<th>Technology</th>
<th>Economy</th>
<th>Social sciences</th>
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<tbody>
<tr>
<td>Meeting with confectioner</td>
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<td>Bread type according to national regulations</td>
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Figure 1. Bread measures: number of alveoli in a given area. (Figure by Sayas-Barberá)

3.2 Determinations in the laboratory of the University

Laboratory work allowed the students to practice rigour and care when operating equipment from the pilot plant, as well as rigorous collection of data. They were responsible of their samples, analysis and data collection. Disciplines involved in the activity include chemistry, physics, biology, food microbiology, food engineering and maths. The laboratory work allows as well the development of general competences such as team work, communication skills among others. Students run the analysis and collected data at the University and then calculate results at High School during science sessions.

3.2.1 Reports correction and feed-back to students

After running calculations, students prepared a brief report that was corrected by High School teachers and then revised by University faculties. This was a necessary step before the preparation of the final report to assure reliable data. Once calculations and briefs were revised students were given feedback from their work and they could proceed with the following step: explain bread characteristics according to the flour used and their composition (protein, fat, fiber...), as well as comparison with national regulations in order to decide on the commercial name of the product (fresh bread, special bread...). National regulations on bread refer to quality parameters as well as commercial denominations of bread. This activity is also related to several disciplines (Table 1), as an example, social sciences are closely related to legislation, however it was not included in the present project for science students. Analysis of data need a deep understanding of bread fermentation and chemistry and involves a great implication of teachers from science departments.

3.3 Presentation of the project in a Science Fair

Students are expected to present the results of the present project in a science fair to be held next year and so provide a deeper inside of the results of the project once all activities have been finished.
4 CONCLUSIONS

A STEM project joined by University and High-School has been designed under a long-term collaborative project, aiming to provide students with access to University facilities and small research projects and engage them in science learning.

The present collaborative type of project requires motivation and involvement from all agents, especially teachers from UMH and HSR. It is also costly for the University, in terms of personnel and occupation of laboratories, and requires the use of equipment and facilities that have to be suited to fulfill the safety measures needed to host young teenagers. It is probably for all those reasons that only 10 projects have been approved for the academic year 2016-2017. Two other experiences have been included in the present project (http://osmosisredovan.umh.es/) and final results are still to be analyzed once the academic year has finished. Aspects to be evaluated are: students’ success on science courses, motivation of students and involved teachers, impact on the progress of the science courses, and degree of coordination among High School and University personnel. Surveys will be run among participants and an external evaluator will prepare the final review of the project. At this time, it can be concluded that food science can provide research projects well suited for High School students, and that close cooperation with local business seem to motivate students and offer a good connection with a wide range of disciplines from STEM to social sciences.

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REFERENCES