Creating a SME, a Project-Based Learning Approach to Improve Knowledge and Transversal Skills on Chemistry Undergraduates

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Abstract

Science education is paying special attention to the requirements of the professional profiles. Indeed, the changes in scientific and industrial environment have arisen the necessity of developing of transversal competences, in addition to the technical and scientific knowledge in Chemistry Bachelor Degree. Project-based learning (PBL) approach can respond adequately to these requirements since enhances the integration of the chemistry knowledge with different professional skills and attitudes, such as teamwork, leadership and management.

This project has been carried out by student of Polymer Chemistry subject in the 4th year Degree of Chemistry from the University of The Basque Country. This subject is devoted to introduce polymer chemistry and physics to last year student. However, the students usually present a lack on the capability to relate their acquired knowledge with a professional environment. Also, the classical teaching approaches miss transversal skills that are required for the new type of enterprises that will form the known as The Industry 4.0. In this project SMEs (Small and medium-sized enterprise) based on polymer industry are being developed by student groups. The aim of this work is to introduce the industrial requirements and improve of skills such as teamwork and leadership. They begin with a product idea from the context of the subject, searching synthetic methods and characterizations, and they have to finish the project with a structure of their SME, including suppliers, logistic and the administrative structure of the hypothetic enterprise.

Keywords: Innovation, Project based learning, Chemistry, higher education.

1 Transferrable Skills and Their Importance for Chemistry Graduates

Chemistry graduates are expected to be capable of understand each reaction taking place in the industrial process but also taking in account the demands of their future professional work, they need to be able to predict properties, raw and process materials requirements, such as storage or delivery conditions. Moreover, the need for a flexible, adaptable workforce to suit the constantly developing and changing requirements of the workplace has forced the development of transferable skills and abilities which are considered applicable in more than one context for graduates.

A variety of labels has been attached to this concept, for example, core skills, core competences, generic skills, personal skills, and personal competence. Indeed, there are variations in the categorization but overall the main emphasis is on developing written and verbal communication skills, interpersonal skills (working with others), problem-solving skills, self-management and foreign language ability.[1]–[9] In addition, the developing of transferable skills can enhance the cognitive development and performance of the chemistry students[10], [11].

This project has been develop as an opportunity within the Polymer Chemistry course to acquire and improve many of the transferable skills that otherwise are quite difficult to develop in the curriculum of Chemistry degree. Chemistry course have been traditionally taught with theoretical and practical approach but far from a professional requirements.

2 Regional Background. The Industry 4.0 and the Basque Country

The Basque Country has become a fast growing region of Spain in recent decades, not only in economic terms, but also in innovation indicators. The prosperity of this region has been connected to its industry-based economy, being manufacturing a core activity. This industry is a very important...
sector for the Basque Country because of its potential to create highly qualified employment and because of its weight in the Gross Domestic Product (GDP). The industrial competitiveness is considered crucial for the Basque Country economy. In this context, the regional government has designed a regional research and innovation strategic plan to improve the specialization within the Science, Technology and Innovation, Plan Euskadi 2020, with three strategic priorities in advanced manufacturing, energy and bioscience-health. [12]

The Basque specialization strategy for advanced manufacturing, known as Basque Industry 4.0, has been identified as one of the strategic priorities. Basque Industry 4.0 promotes the creation of new products, the incorporation of new materials and the improvement of manufacturing processes, through the incorporation of digital technologies that provide efficiency, productivity and sustainability in industry.[13]

Considering the impulse of the regional government to Basque Industry 4.0, the transferable skills are essential to improve the employability of Chemistry graduates. In consequence, the main aim of this complementary project for Polymer Chemistry course is to provide last year students with wide range of activities that improve transferable skills essential to prepare them adequately to be a highly qualified workforce.

3 PROJECT-BASED LEARNING IN POLYMER CHEMISTRY COURSE

Project based learning was applied in “Polymer Chemistry”. This course is taught by the Department of Physical Chemistry of University of The Basque Country at the second semester of 4th year of Chemistry bachelor degree. The project was presented to the students as “Make your own polymer-based SME”. Among the objectives set by the course program, those of particular relevance that they have to be developed in this work are: to improve communication skills, to be able to use the acquired Chemistry related knowledge in a work environment, and to strength professional skills.

The most important role of the tutor is to act as facilitator, enabler and mentor for the project, also it is important to provide a valuable guidance to facilitate the connection between the theoretical part of the course and the students’ projects. It is highly recommended to underline this relation to improve the links between the course and the project, in order to improve transferable skills more related to Chemistry degree.

3.1 Introduction to the project. What is a SME? SME Structure

The projects were structured around the creation of a polymer-based SME where students form management team (5-6 people) of the company, and they have to develop a polymeric product. The student groups were set by mixing classmates with “unfamiliar” students (i.e. those who do not usually work with) as a way to challenge working environment. The project is developed along 5 activities. The objective of the first activity is to introduce to the project. The students have to describe what a SME is, define their SME, products and develop the management organization chart of their SME. SMEs require a management structure that will allow performing realistic tasks related to a polymer-based enterprise, such as market research, sales and financial accounts, human resources, production and product development, logistics and storage, among others.

The Fig 1 shows one management chart developed in the course. The number of managers is defined depending on the group size, in the chart of Fig 1 five students took part, so the chart has a General Manager and other four managers, finance, marketing, production and human resource (HHRR) managers. Usually, the charts have had 4-6 managers to get an equilibrate work distribution between the students, considering that their SME structure have to cover the main management requirement of a real SME.
3.2 Student’s role assignment and tasks.

Once the management charts have been developed, in the second activity, students have to discuss the role assignment to each group member. In this activity, the managers have to describe their department activities and structure. Managers have to define both their individual task and the ones that involve other managers. The professor should challenge the student to work together in group to improve the team work and problem-solving skills.

The SME’s require a management structure that will allow performing the tasks related to a polymer-based enterprise, such as market research, sales and financial accounts, human resources, production and product development, logistics and storage, among others. As a reference some the tasks of the SME of Fig.1 are going to be described below. In this project an enterprise devoted to intracocular lens was developed. Their organization has 5 members: general, finance, marketing, production and human resources managers.

3.3 Human resource manager

One of the main challenges of a new graduate is to figure out how their first approach to the work market is going to be. Human resource manager has to create SME’s workforce framework. It is highly important to novel employes, as undergraduates, to know the Collective Agreement for the Chemical Industry in the Basque Country. Each manager has described their HHRR needs and they have to agree the salary of each employee considering the Collective Agreement. In Table 1 the staff’s salary and working timetable is resume.

<table>
<thead>
<tr>
<th>Staff</th>
<th>Salary (Without taxes)</th>
<th>Social Security (%35)</th>
<th>Timetable</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Manager</td>
<td>30604.54 €</td>
<td>10711.59 €</td>
<td>09:00-13:30 15:00-18:30</td>
</tr>
<tr>
<td>Managers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>25186.56 €</td>
<td>8815.30 €</td>
<td>1: 06:00-14:00 2: 14:00-22:00</td>
</tr>
<tr>
<td>Non-graduate workers</td>
<td>18888.91 €</td>
<td>661.12 €</td>
<td>1: 06:00-14:00 2: 14:00-22:00</td>
</tr>
</tbody>
</table>
In addition, the RRHH manager has to develop with the collaboration of other managers the Safety training for all employees. It is important to describe all the risk of the SME and prevention policy. Fig. 2 shows an extract of the Safety training developed in this activity.

3.3.1 Production manager

Production manager is in charge of the fabrication of the products. Based on the knowledge acquired in the theoretical classes of Polymer Course, the fabrication process, raw materials and equipment required for the fabrication are described in one of the tasks. The raw material and equipment budget have to be done between production manager and financial manager, as a responsible of purchases. In Fig 3. an extract of the production dossier is shown.
3.3.2 Marketing politics

Chemistry undergraduates, even in their last year, usually have issues with the market based assignments. The tasks of this manager are related to the prices of the products, distribution and marketing policies. The students also have to develop their brand, not only their SME name, product name and company logo (Fig. 4). The price of the products usually is decided not only by the marketing manager also the other managers should help in the decision based on the different costs such as the fabrication or human resource.

3.4 Seminars

In the third activity, by the time the students begin with their task several problems will arise, since they have to manage lot information coming up from their research. Often this information could be not related to a chemistry degree, so at this point it has been extremely helpful for the students to receive some expert’s seminars to confront these problems. We have selected a group of professionals that are chemistry graduates but they work as a financial, general or safety manager in SME or Research Centers in The Basque Country. In the seminar they explain their professional activities, which are the main transferable skills required for chemistry graduate students and answer students question related to their career. This part of the activity has high success, not only because the help that students can get in order to complete their SME, also the interaction with the professionals with the same
background than they are going to achieve give them a very valuable opportunity to realize how the professional world looks like.

3.5 Project assay and presentation.

The final assignment of the project is to write an assay with all the information obtained from the different tasks. In addition a presentation of the created SME is performed by each team, during the presentation other teams could ask any question related to the project.

3.6 Evaluation of the classmates’ projects

Finally, each group has to evaluate the assay and the presentation of other groups’ projects and present and objective evaluation of one page of each project. In the evaluation the project is rated not only for the value as SME, also it is important to underline that the evaluation have to reflex the “product is sale”, that is, if they have been able to develop an interesting product with the assay and presentation.

4 CONCLUSIONS

Very positive feedback and evaluations were provided by students. Our feedback of the industrial employers mentoring their summer internships has been also very positive. Their mentors remark the improve in communication and problem solving skills in those students that have studied Polymer Chemistry course compared to others that they have not. In addition, employers confirm that students are efficiently involve in work dynamics after this course and they need training period. The simulation of SME, we believe that improves not only the transferable skills of our students, the activity also gives them a valuable approach of what a SME is and which kind of work assignments a chemistry graduate could have in the industry.

This project enables the development of team working, problem-solving skills, and communication skills during SME creation process. Also, the final evaluation of the classmates improves the critical thinking of the students. Overall, the results obtained from this project-based learning approach have been excellent for the students, giving them a more qualified background in order to obtain a successful employment.

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REFERENCES


