Challenge for Freshman Students: Writing an E-book of Chemical Engineering

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Abstract

In 2012, the University of Sao Paulo (USP) created the Program of Academic-Scientific Tutorial to reduce the scholar evasion of freshmen from families with low income. The main goal is to encourage students to invest in the search of knowledge of the basic elements needed for the development and implementation of undergraduate research projects so that they can be qualified in order to act in their second year of higher education course in research programs. The program requires close supervision of a faculty member to assist the student to understand the mechanisms of scientific methodology and prepare an undergraduate research project. It is also expected from the professor to act as a tutor in order to help the new students to get to know the University and to be fully integrated into it. This paper describes the experience of a tutor with a group of four freshmen in a course of Chemical Engineering, during the year 2012: the production of an e-book on Chemical Engineering. The tutor challenged the students to write an e-book to be made available to other students in the Chemical Engineering School. The e-book had nine chapters, being the first (Introduction) written by the tutor and the other eight chapters written by four students, where each one wrote two chapters. In this project, students have developed many skills that would not have been developed if they had just followed the regular first year of engineering. They developed the skills of scientific methodology, written communication, teamwork and creativity.

Keywords: project based learning, competences, chemical engineering.

1 Introduction

For hundreds of years, all over the world, teaching has been done. However, the act of a teacher teaching does not ensure that the student truly learns. The traditional method of teaching is still widely used, for it is the professor who, during his class, conveys knowledge to the student in a passive teach-learning process. While the teacher talks and writes on the board, the student takes notes on his notebook. This is a passive method of learning, because the interaction between the teacher, in the role of transmitter of knowledge, and the student, in the role of receiver, is very low.

A situation sought by many who act in the teach-learning process is that in which teacher and students work together in the building of knowledge, in which the teacher is the facilitator who assists in the learning by the student. This way, the student is not only a passive receptor of knowledge, but also an active participant in its building. (Agnew, 2001)

One of the main obstacles of education is utilizing learning methods that reveal themselves attractive to the student, allowing the gaining of solid technical knowledge and developing soft skills.

Currently, technological changes occur in an increasingly accelerated rate, teaching is a major challenge. On one hand, teachers having to adapt to this new world of technology. On the other hand, the student, worker of their learning, dealing effortlessly with these changes. In this environment, where the student seems to be acquainted to information technology (e.g. laptop, tablet or smartphone), the act of learning is interactive and ensues from the concrete situations experienced in their daily lives.

Project-Based Learning (PBL) is a method of active learning that has the objective of engaging students in acquiring knowledge and skills through a real activity, which is well planned. In practice, what is done is to introduce the students to an open problem, so that, trying to fix it, they acquire the technical knowledge desired and develop technical skills such as ability to problem-solving, oral and written communication, and teamwork, among others. (Duch et al. 2001)

The use of PBL always requires a final result, which may take various forms, such as a prototype, a software or a book. It can also be a consistent report describing a procedure used in the preparation of a product.

Among the many methods of working with PBL, in 2012, the University of São Paulo (USP) created Program of Academic-Scientific Tutorial with the goal of integrating the freshmen, to their undergraduate programs, in a more efficient manner to the teaching and research environment of the university. The goal of this program is that each participating student delivers an undergraduate research project at the end of his first year of university. Thus, these students will be able, from their second year at university, to implement programs for undergraduate research.

1.1 Purpose

This paper presents a specific situation, related to the Tutorial Program, involving one tutor and four students entering the undergraduate course of Chemical Engineering in the School of Engineering of Lorena (EEL) of USP in 2012. Within this program, the advisor suggested to the students to write an eBook. Once they accepted the challenge, the theme chosen was Chemical Engineering.

The objective of this paper is to describe the process that led to the production of the eBook and determine that the students involved were able to develop a set of technical and soft skills that would not have been developed if they had just stayed as standard students of their courses.

2 Project Based Learning (PBL)

According to the Project Management Institute (2008), a project is a temporary endeavor undertaken in order to create an exclusive product, service or result - its temporary nature indicates well-defined beginning and ending. A project has a defined duration that can vary from a few months to a longer period, sometimes up to one or two years, with a well-defined delivery.

Project-Based Learning (PBL) is a method of active learning and its aim is to engage the students in acquiring knowledge and skills through real activity that is well planned. In practice, Project-Based Learning presents the students with an open problem, so that, in the search for a solution, they acquire skills such as problem-solving abilities, oral and written communication, and teamwork, among others. (Duch et al. 2001). Learning is a constructive process, so the students obtain knowledge is previously; skills such as setting goals, finding the best way to solve problems and assess the results are essential for learning, and the assignment of problems that students will face as future professionals. (Ribeiro et al., 2003)

According to Ribeiro (2005), the main differences between this new teaching method the traditional approach is that teaching is student-centered and the teacher is only a facilitator of the learning process: problems are used to direct and focus on the learning. To Hadgraft and Holecek (1995), professionals trained through PBL have the ability of solving problems in situations that are not part of the routine, possess critical and creative thinking, can relate better in teamwork and always seek more learning.

This method is based on the usage of real-world problems so students may develop critical thinking skills and knowledge in the desired area. Problem-based learning is an innovative method, as it involves several educational theories into one single activity and also poses challenges for teachers and students. To Gijselaers (1996), the role of the teacher is to guide, lead, the group, to support and help students to identify the knowledge required to solve the problem. The PBL method is associated with the building of knowledge, which is not absolute, but gradually built and expanded by the student (Brandão et al., 1998; Camp, 2006).

PBL is an alternative to passive learning (Zastavker, Ong and Page, 2006) as it happens in many conventional higher education courses.

This methodology is part of an educational philosophy, because when the students keenly engage in solving a problem, from the beginning to the end, they are developing skills in problem solving, very necessary in their professional life (Zastavker, Ong and Page, 2006). For Powell and Weenk (2003), when the student is encouraged to take on the central role in their learning, where the teacher ceases to be the sole responsible for the transmission of knowledge, the paradigm of passive learning changes to an active one. Thus, learning becomes broader; for the active learning techniques are based on research for solving problems. (Powell and Weenk, 2003; Powell, 2004).

For Lu (2007), students who engage in project-based learning, compared to students from the passive method, are more motivated, exhibit better communication skills, are better on teamwork and have a more efficient understanding of how to apply their knowledge to solve real problems.

Therefore, PBL represents a very broad category of learning, for the techniques based on scientific research are often used. A fundamental feature of PBL is to allow the student to interact with other areas that are not directly part of the problem. Thus, learning has a wider scope, a holistic view. (Barrows, 1986).

3 Methods

This item presents the research method used, as well as describing in detail the Tutorial Program established by USP and its evolution in the context of a tutor and his four students.

3.1 Research Method

The research method employed was of bibliographic research of exploratory character and qualitative nature. The focus was on the review and critical analysis of literature. For Gil (2010), this method provides an overview of a particular subject.

This research method provides means that assist in the definition and resolution of problems already known. It also allows for a certain topic to be examined in a new light, allowing new conclusions. Furthermore, it allows the coverage of a range of topics, especially when the research problem requires the gathering of data.

Gil (2010) states that there are no set rules for conducting literature searches, but some tasks that are relevant.

This research method allows grouping all the information collected into a single database, of which the sources are in the scientific bases, libraries, universities and websites in general, among others.

A research guideline was suggested by Gil (2010) and adapted for this study was followed. It consisted of the following activities: A) Choosing the theme; B) Surveying preliminary bibliography C) Reading Material, D) Doing a book report, E) Logical organization of the subject and F) Writing the text.

3.2 Program of Academic-Scientific Tutorial

Program of Academic-Scientific Tutorial requires the availability of a teacher, to perform the role of tutor to guide the student on his first two semesters at the University. The tutor has the mission of helping the student to understand the mechanisms of scientific methodology and to prepare a research project. Moreover, this tutor should help the freshmen to get fully integrated in the University, acting as an advisor and guide to him.

In summary, it is expected from the tutor to be responsible for monitoring the student in all academic activities and have him to the write a research project compatible with his first year of undergraduation. On the other hand, the student also has responsibilities, as it is expected from him to: 1) Develop, with responsibility, all academic work assigned by his tutor, 2) Attend meetings and be punctual and 3) Develop a research plan as a result of all the work carried out over the year. The first step of the tutorial program was the submission of projects by the teacher.

The teacher wrote projects related to two lines of research on the interface between chemical and industrial engineering: A) Use of Lean Management tools and concepts of sustainability in the chemical industry; B) Reverse logistics of waste from the chemical industry. These are wide lines of research, in order that each student can identify a particular theme on them.

Annually, the School of Engineering of Lorena USP welcomes 360 new students in its six undergraduate Engineering courses. Students entering in 2012 and enrolled in the first semester of the course were invited to apply as candidates to work on the scientific academic tutorial projects submitted by teachers.

The selection of students was held by the USP's Undergraduate Student Affairs Office based on two criteria: a) the socio-economic profile of the student and b) performance in the Entrance Examination. Note that the socioeconomic profile was used because the selected students would receive a stipend to work on the projects. After the choice was made, the selected students were directed to the tutor.

The tutor submitted the projects on March of 2012. The students applied in April and the selection took place in May of 2012. In June of the same year the selected students started working, and by March of 2013 the work was ended.

3.3 Development of the tutorial

At the beginning of the tutorial, the tutor held some meetings with his students in order to better know the profile of each of them. Furthermore, he strongly encouraged them to interact with senior students of the same degree who were completing the undergraduate thesis under his guidance.

In the first three months, the teacher held several joint meetings with the four students who were under his guidance. At these meetings, the focus was on: a) the development of each in his undergraduate course and b) in the first steps of what science is and how it is produced.

In these early months, each of the students began to search for a line of research within the ones presented by the teacher. This was not a scientific search, but one with greater emphasis on Google Scholar and similar mechanisms. This was important, as a starting point, because it provided each of them a minimum knowledge on the subject under their responsibility. Then they began the search for scientific sources, starting by reading conference papers related to the projects in which they should work on.

At the end of the third month, the students began to read masters dissertations and doctoral theses. After reading, the students wrote a summary of the work read including the following information: aim, justification, research methodology and main results.

Between the fifth and sixth month, the tutor worked on the main concepts of research methodology, presenting the main research methods in engineering. Then the students returned reading masters dissertations and doctoral theses, but now focusing on the research method used in this work. They developed new summaries of the papers read, but with focusing and detailing the research method (definition of the universe and survey sampling, method of data collection, survey instrument used and the system of analysis and interpretation of data).

During all this time, the tutor guided the students' path regarding the consultation on advanced scientific databases, and each one of the students the chose what and where to search in the international scientific journals.

After six months, each student had already chosen the subject to write his undergraduate research project. From the seventh to the tenth month, each student worked on the development of his own research project.

3.4 The idea of the e-book

Between the third and fourth months of tutorial, the professor proposed to his students a challenge: to write an e-book on a theme common to all.

The eBook was not part of the Tutorial Program context. This was an idea that came up and was welcomed by all. It was determined that the e-book would have nine chapters. The first one, the Introduction, written by the tutor and the remaining eight, written by the four students.

Due to that, from the fifth month of tutorial, each student worked simultaneously in two research fronts: A) the individual research project that should be delivered as the final product of the tutorial and B) the two chapters of the book that were his responsibility.

The next topic presents the research projects developed by each student at the end of the tutorial. These research projects are relevant to the context of this paper, as they evidentiate the competencies developed by students during its preparation.

The construction of the eBook, main purpose of this paper, is recommenced after the presentation of research projects.

3.5 The Research Projects

The development of an individual research project by each student, contributed a lot for him or her to develop an e-book of higher quality. That because each research project was on a very specific technical issue, which contributed significantly to the improvement of the students in research methodology and in written communication.

During their tutorial two students worked on the research topic A: Use of Lean Management tools and sustainability concepts in the chemical industry.

The research project proposed by one of the students was "The study of the purification of biodiesel obtained through homogeneous catalysis with the use of adsorbents." The student explains that with the increase of energy demand in the world it is necessary to explore new renewable sources, whereas petroleum, natural gas and coal, the main explored sources nowadays, have finite capacity. Thus, biodiesel appears as an alternative prominent source, for it is a biodegradable fuel and renewable source - capable of substituting diesel fuel in internal combustion engines with satisfactory results. The intended goal of Scientific Initiation is to improve the production process of biodiesel using adsorbents, thereby targeting a greater economic and environmental advantage. The research will be done in a laboratory and the student presented on her research project, the details of each of the experimental steps to be performed on the Scientific Initiation research.

The research project proposed by the student who worked in this line of research was "Sustainable development of the energy matrix focusing on oil activities." An energy matrix consists, among other energy sources, of: A) cleaner source, which causes low impact on the environment, such as wind power and hydroelectric and B) not so clean sources which are those related to fuel burning and combustion, especially coal and oil. Due to that, the search for alternative energy sources is increasingly relevant. However, in order to be viable, it must have an adequate relationship between cost and benefit. The intended goal of Scientific Initiation is to conduct textual research, through a broad bibliographical research on the main International Journals of Chemistry and Petroleum Engineering and the regulatory offices of the energy matrix in Brazil and the world. It is intended to focus on sustainable development with a greater focus on oil activities.

The other two students, during their tutorial, worked on the research line B: The study of Reverse Logistics of chemical industry's residues.

One of the students who worked on this research line suggested the research project title of "Mapping active and passive waste residues from the undergraduate laboratories of the Engineering School of Lorena ". The student recommends the creation of a Chemical Waste Laboratory in the Engineering School of Lorena in order to treat and recuperate the waste generated in the disciplines of the undergraduate courses. The experimental research method is suggested by the student through a sequence of seven very well defined stages by the student in her research project.

The other student who worked on this research line suggested as the research project the "Improvement of the Process of Recycling Paper". The student elucidates that, in recent decades, the waste has become a major concern to men, since its accumulation in inappropriate places is very common. Thus, recycling is one of the key ways to reduce this waste. She explains that recycling works as a reverse channel, as the waste is processed into raw material. One of the main recycled product is paper. The aim of her Scientific Initiation proposal is to study the process of paper recycling, especially the stage of removing paint from it, through experimental research. She explains that she will build, on a laboratory scale, a replica of the paper recycling process performed by the industry in order to specifically assess the stage of ink removal.

4 The chemical Engineering e-book

After defining the theme "Chemical Engineering", in a group, it was evaluated which would be the target audience to whom the book would be aimed. It was determined that the main expected eBook audience would be of high school students interested in learning more about chemical engineering. In addition, another important audience would be of freshmen in chemical engineering course.

4.1 The building of the e-book

Having the main e-book objectives set, as well as its basic structure, the main issues to be addressed were also set. The book's chapters were structured to be: 1) Introduction, 2) History of Chemical Engineering; 3) Field of Action of Chemical Engineering; 4) Chemical Industry; 5) Supply Chain in the Chemical Industry; 6) The chemical industry and sustainability; 7) Frontiers of Chemical Engineering; 8) Challenges of Chemical Engineering; and 9) The future of Chemical Engineering.

Each student was responsible for two chapters of the e-book, and these were distributed randomly.

Since the production of the eBook occurred simultaneously to the development of each student's main project in the last six months of tutorial, in the preparation of the two chapters under its responsibility, each one of them took the same steps that were taken in their individual research project. Over the six months of the book's effective development, the students read about the topics related to their chapter of responsibility. Then they developed a summary form in order to organize the issues relevant to their chapters. There were some specific meetings at this stage to discuss the structure of the book.

The chapters have been written and rewritten several times by each of the students, and always under the supervision and correction of the tutor. They encountered considerably more difficulties in the preparation of the chapters of the book than in their individual research projects, since the tutor would always insist on that everything that was being written should be solidly grounded, ascertained. However, this was a rich period of improvement of their written communication skills, for amongst the preparation of the first draft and the final version, each of them wrote at least six versions of the assigned chapter.

As the written versions were being enriched, unreliable sources were being replaced by scientific sources of known reliability, such as books, journal articles and scientific doctorate theses. Gradually, each chapter was shaped and built based on solid references.

During the last six months of tutorial, each student was learning and understanding better, while writing the eBook and his personal research on scientific methodology and research protocols.

4.2 Developed competencies

Throughout this project, the students developed many competencies that would not have been developed if they had only followed their regular first year of engineering. Among others, the development of scientific methodology skills, teamwork, creativity and written communication stand out.

Scientific Methodology: The goal of scientific research is contribute to the building and expansion of knowledge in all sectors of science through a set of systematic and controlled thinking called, defined as, scientific method.

Generically, the scientific method is the method by which a researcher develops his studies.

In a broader sense, the scientific method is the process of scientific research that has, as its starting point, the definition of a problem, which will affect all other stages of the development of scientific research, to be studied. These stages are the method to be used, the theoretical outline that helps to explain the problem, the sampling method and data collection, data analysis and, finally, the conclusions and recommendations (Grohaug and Ghauri, 2010).

The development of this competency took place throughout the entire work, with a major emphasis on the beginning of the fourth month. It began with the development of summary forms of the performed, assigned, readings. It went through the learning of theory, conducted by the professor, one of the main research methods in engineering. Then they read the theses and wrote their summary forms focusing on how the different research methods were used. After that, group meetings were held, where each student had their summary forms prepared and discussed the details of the research methods used in the analyzed studies. Finally, each student developed a specific chapter of scientific methodology, with a good degree of detail, in their individual research project.

Teamwork: is one of the key foundations of high performance organizations (Tomelin, 2001), for tuned teams lead to increased productivity in their activities, are more creative and efficient in solving problems and are always working towards a continuous process improvement (Robbins and Finley, 1997).

In a plain way, teamwork is defined as the ability to advise and obtain cooperation from your colleagues in activities you have common goals.

Teamwork is the ability of working with formal and informal groups of stakeholders (Bernotavicz, 2002), with the goal of achieving cooperation and compromise and to seek vision-oriented results concerning shared goals (Oderich, 2005).

The development of this competency took place throughout the entire work performed through: a) the cooperation among them, that was possible to be observed on the meetings with the tutor, where in the first few months each of the students showed great interest in their individual projects, but in recent months, the interaction between them was too great; B) the cooperation among them in the numerous informal meetings that were held to help each other and C) the compromise, especially with the book, which was a job where each one had their specific part, but the end product was of interest to all.

Creativity: is a term used very often in all segments of human life, every time we refer to something surprising, related to the processes and mechanisms of thought, and related to the new, the imagination, the excitement, the unexpected, innovation, originality, inspiration, intuitive ability, boldness, insight, detachment, enlightenment. It is about something unheard of, which was born from nothing, linked to curiosity, to paradox, to invention, to a certain amount of mystery, complexity, improvisation, unpredictability (Vidal, 2000).

Creativity is the ability to develop innovative solutions (Gramigna, 2007; Oderich, 2005), feasible and appropriate to the situations presented (Gramigna, 2007) and focused on the modernization of methods and processes (Oderich, 2005).

This expertise was developed throughout the work. Each one of them, in different degrees, finished this process of tutorial, more creative than when they started. This is somewhat intangible, but perceptible to the eyes of the tutor. At the beginning, each one of them spoke little and gave mere ideas on what direction to take. Throughout the work, understanding they were free to express their ideas, they loosened up and accepted new challenges, one of them being the e-book produced.

Written communication: Communication is a two way process that involves the transmission and reception of messages between an emitting source and a receiving end, and takes place between individuals.

Houaiss (2013), in his dictionary, as one of the definitions of communication, in a broad sense, the act or circumstance of communicating, which consists of the action of conveying a message and eventually receiving another message as an answer.

The concept of communication between individuals consists in the ability to communicate clearly, accurately and effectively with others, mainly taking place mainly in written and verbal forms (Bernotavicz, 2002; Oderich, 2005).

For a researcher, communication is important in the process of scientific production and dissemination, which usually occurs through the formal channels of research (Gil, 2010). The result of a scientific research is published in written form in conference proceedings, scientific journals or patents, through a source (the author of the research) and recipients (members of the scientific community in general).

Usually in engineering, the students work on this competency very little during their first year. In EEL's course curriculum, the first year of engineering is focused on the basic sciences (mathematics, physics and chemistry) of engineering. The student works intensely on logical reasoning by solving a series of exercises, where there is a prevalence of numerical calculations, mathematical formulas and equations of physics and chemistry. In the tutorial, they developed written communication skills. Between the third and tenth months of tutorial each one drew about 30-40 summary forms, where they wrote a personal summary of academic work of other authors. At the end of the tutorial, each of them wrote about 40 pages, half of them on the chapters of the book and the other half on the individual project. Regarding the book's chapters, the stringency of the tutor was much higher than when compared to the individual projects. This is because few will read the research project, while the book will be read by many and will be widely publicized. Therefore, the review of the written text in each chapter of the book was done numerous times.

4.3 Gains attained by the students

None of the four students involved in this project thought that, entering the university, they would have had the experience developed in their first year engineering. For each one of them expected to simply drift through the course successfully during this time.

The Tutorial Program, through the guidance of the tutor, allowed each of them to have relevant gains, among which are: A) The insertion within a research environment with a strong understanding of scientific methodology and B) a higher professional growth and maturity they would have if they had simply attended their regular first year of engineering.

The gains obtained by students are not easily measured. However, these gains will be of significant difference in professional and personal life of each one of them. The major evidence of all of this, is that among the 360 freshmen of 2012, they are part of a select group of no more than 20 freshmen students, who had their academic and scientific development accelerated and also produced a tangible result: two chapters of an eBook.

5 Conclusion

This paper describes the process of producing an eBook done with the active participation of four freshmen from the Chemical Engineering course at the Engineering School of Lorena USP. The paper describes how the process took place and walkthrough that culminated on the production of the e-book simultaneously to the other commitment that the students had with Scientific Academic Tutorial Program at USP.

The development of the e-book was an innovative and complementary proposition to the goal of the Tutorial Program. It conveyed on gains in research skills and written communication to the students, and those were higher than the students would attain if they only wrote the research projects.

In addition, the students involved acquired a set of soft skills that would not have been obtained had they remained just as normal students of their courses. Among others, the development of scientific methodology skills, teamwork, creativity and written communication stand out.

The main product, that is tangible, is the e-book on chemical engineering.

However, the intangible products, but extremely relevant are: a) the real learning about scientific methodology, b) the development of soft skills, c) the inclusion in the research environment of the University and d) the faster career maturity.

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