Starting the Self-learning through Hybrid-PBL Design in a General Chemistry Course

Patricia Morales Bueno
Department of Science, Pontificia Universidad Católica del Perú PUCP (Perú)
pmorale@pucp.edu.pe

Abstract

For several years, an interesting alternative for science education at university level has been Problem Based Learning. It is an educational vision that promotes open, reflective and critical learning with a holistic approach to knowledge that recognizes its complex and changing nature, and involves a community of people who interact collaboratively to make decisions in relation to different problematic situations they must face. In this sense, PBL is the mean by which it is possible to establish the conditions conducive to active, contextualized, integrated and comprehension oriented learning, providing opportunities to reflect on the educational experience and to practice applying what have been learned. However, PBL implementation is not an easy task, since it depends on several critical factors, mainly related to the characteristics of institution, teachers and students. Therefore, implementation of hybrid PBL is quite common in universities that maintain a traditional structure and organization. However, this does not constitute a contradiction with the purpose of promoting self-directed, but rather implies that teachers constantly review and adapt their strategies for implementing, adapting to the specific educational learning situation. In this paper the results of the application of a hybrid-PBL strategy in a General Chemistry course from an engineering faculty is reported. The strategy had to be adapted to a rather structured design to facilitate the learning of students with no previous experience in self-learning. The study focused on the achievements in learning concepts, procedures and applications of the subject of Ionic Equilibrium, considered especially difficult for students.

1. Introduction

For some years, the trends in higher education involve a substantial change of conceptions about the process of teaching and learning. In this sense John Biggs proposes a model that identifies three levels of thinking about university teaching, being the third level the ideal goal that should be targeted [1]. At the third level, attention is fixed on *what the students do* and, in that sense; education is seen as a mean to support learning. This involves both cognitive abilities and learning contents through the development of strategies for inquiry, searching for information, solving problems and raising new questions. PBL methodology is located on the third level of Biggs model, it is an educational vision that promotes open, reflective and critical learning with a holistic approach to knowledge that recognizes its complex and changing nature, and involves a community of people who interact collaboratively to make decisions in relation to different problematic situations they must face [2, 3, 4]. During PBL process, students are confronted with real-life scenarios or a problem that requires a solution. The problem is complex enough so that the solution is not obvious. Students must analyze the problem and the context and apply higher order reasoning skills and knowledge to find possible solutions. PBL and scientific method of inquiry share a similar structure of open-ended inquiry, question asking, appeal to prior knowledge, research, hypothesis testing, analysis and reporting the results and solutions. This converts PBL in a particularly appropriate proposal in the context of science education [5].

However, PBL implementation is not an easy task, since it depends on several critical factors, mainly related to the characteristics of institution, teachers and students. Therefore, hybrid PBL models are quite common in universities that maintain a traditional structure and organization. This does not constitute a contradiction with the purpose of promoting self-directed, but rather implies that teachers constantly review and adapt their strategies for implementing, adapting to the specific educational learning situation. In this regard, some authors conclude [6, 7] that the approach taken by the facilitator should not be the same in all PBL situations but needs to adapt to the level of the student and the curriculum in which PBL is being implemented.

In this paper the results of the application of a hybrid-PBL strategy in a General Chemistry course from an engineering faculty is reported. The strategy had to be adapted to a rather structured design to facilitate the learning of students with no previous experience in self-learning. The study focused on the achievements in learning concepts, procedures and applications [8, 9] of the subject of Ionic Equilibrium, considered especially difficult for students.

2. Context of the Study

A hybrid PBL approach began to be implemented in chemistry courses of Sciences General Studies at PUCP since 2001. The successful initial results were changing over time when some aspects for the university admission process were modified. Thus, students in the early years have very little experience in self-learning. Consequently, the hybrid PBL model was modified incorporating more facilitator interventions particularly to develop reasoning skills and metacognition in students. The main goals were to promote: the construction of meanings for concept learning, learning strategies to organize information build and internalize models and, applying reasoning skills to the use of knowledge in different situations.
Commonly, Ionic Equilibrium is perceived as a difficult topic by freshmen engineering, so that the present study was conducted in the framework of this topic learning. Figure 1 shows the process design applied.

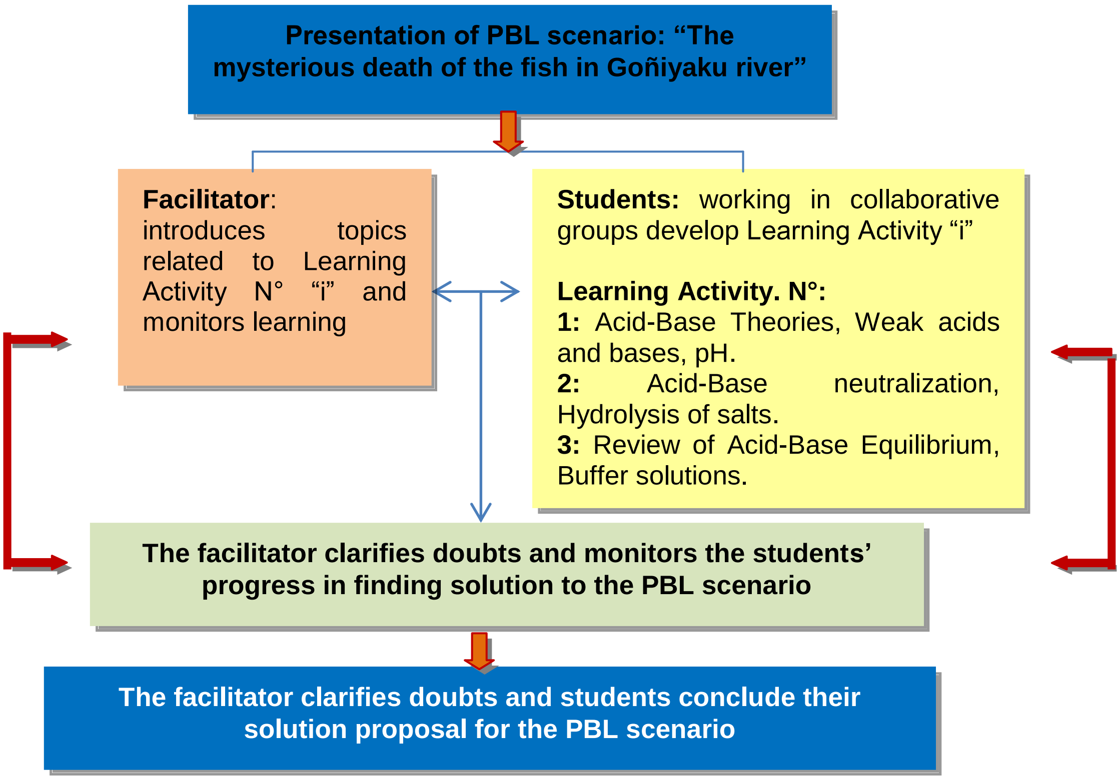

Fig. 1. *Process design applied in unity "Ionic Equilibrium" in a General Chemistry course*

3. Methodology

3.1 Participants

In this study, three different cohorts of first year engineering students were considered; each one was enrolled in a General Chemistry 2 course in a different semester. Groups 2013 and 2014 began their studies at PUCP under the new modalities of admission; Group 2008 began its studies under the previous admission process. The new process design for the unity "Ionic Equilibrium" was applied with the Group 2014. Table 1 summarizes the groups' characteristics.

Table 1. *Characteristics of the participating groups*

Group	N	Age	Gender (%)	
			Male	Female
208	53	17 - 22	81,1	18,9
213	63	17 – 21	81,0	19,0
214	63	16 - 21	77,8	22,2

3.2 Instrument

The instrument used in this study was a test elaborated following Sugrue's model for evaluating three levels of Knowledge Structure: concepts, principles and link concepts and principles to conditions and procedures for application. The details of the construction and validation of the test have been reported [10]. Final scores on the assessment are out of 110 possible points. There are 50 points possible on the first level (concepts) (1 question with 5 items), 30 points possible on the second level (principles) (1 question with 3 items), and 30 points possible on the third level (link concepts and principles to conditions and procedures for application) (3 items). The format used for the test was multiple choices. The items are formulated in such a way that for the first level, the student should identify examples of the concept. At the second level, the student should select the best explanation of a particular event and in the third level, the student must select the correct procedure to identify concepts in a given situation, or select the most appropriate procedure to change a concept status manipulating another concept. The degree of difficulty of the test is 51,24% and the biserial point coefficient (rpb) is located in the range 0,463 to 0,586 for all the items.

3.3 Procedures

The test was administered to all the groups at the end of the unit "Ionic Equilibrium". Only in the case of Group 2014, the instrument was administered as pre- and post-test. Changes in each level between pre- and post-test results were measure in Group 2014 by mean of the Change Index (CI) calculation. This index represents the percentage of advance or backward of the post-test score taking as reference point the pre-test score, this way its variability oscillates between a minimum value of -100 and a maximum value of +100.

3.4 Analysis of data

The data were analyzed using Statistical Package for the Social Sciences (SPSS) 19 software ®. The level alpha was established a priori in 0,05. From the data collected, a descriptive analysis of the scores obtained in each level and the whole test, as well as values of change index (CI) obtained was performed. In order to verify the differences between the participant groups, the analysis of variance (ANOVA) was used, considering as dependent variable the scores corresponding to the three levels and the whole test and, as independent variable the Group. For all the analysis the scores were expressed as percentage.

4. Results

Table 2 shows the descriptive statistics for pre- and post-test scores obtained by Group 2014, including the descriptive statistics for Change Index (CI) values. The greater CI values were obtained in the first two levels related to the understanding of concepts (first level), and of principles (second level).

Table 2*. Descriptive statistics for pre- and post-test scores and Change Index obtained by Group 2014 (N = 63)*

Level	Pre-test		Post-test		Change Index	
	M	SD	M	SD	M	SD
1	16,33	28,244	77,62	24,476	70.59	32,134
2	2,65	9,572	54,50	39,731	51,48	43,798
3	15,87	23,078	31,21	23,862	8,20	49,267
Total	12,48	14,856	58,65	20,910	53,02	21,993

Table 3 shows the descriptive statistics for the scores obtained by the three groups considered in the study, in each level and the whole test when this was administered at the end of the unit.

Table 3. *Descriptive statistics for the test scores obtained by the groups considered in the study*

Level	Group 2008 (N=53)		Group 2013 (N=63)		Group 2014 (N=63)	
	M	SD	M	SD	M	SD
1	69,44	23,730	60,06	25,818	77,62	24,476
2	33,53	32,251	34,60	37,196	54,50	39,731
3	45,26	23,675	34,91	25,709	31,21	23,862
Total score	53,05	18,397	46,27	18,271	58,65	20,910

The ANOVA analysis of the scores revealed significant differences between the groups in the three levels and the total score. The Tukey-b post hoc test revealed that Group 2014, with which the new process design for the unity “Ionic Equilibrium” was applied, obtained the higher scores in the second level (principles) and the whole test and the differences with the other groups were significant. Although the first level (concepts) score was the highest for this group, no significant difference existed between this and the score obtained by Group 2008. The results in the third level were similar for Groups 2013 and 2014, the higher score was obtained by Group 2008 and the difference was significant.

5. Conclusions

The results obtained in this study clearly show the effect of incorporating structural elements in the PBL process. While there are significant gains in understanding concepts and principles, it is not possible to say the same of the achievements in the application of these concepts and principles to new situations.

One of the main goals in PBL implementation is related to the development of skills for solving problems, especially those that help students to develop flexible cognitive strategies that prepare them to face and discuss unexpected situations in their professional performance to find meaningful solutions. The primary objective is linked to achievements in the third level of knowledge structure of Sugrue’s model. Subjects with good performance in solving problems must be able to recognize situations where procedures can be performed to identify or generate instances of a concept and should be able to perform these procedures exactly. Overall, must be able to implement a process based on a principle to build a desired achievement in a new situation.

However, the context in which the learning process takes place must be appropriate to facilitate the good performance of students, even if it means reviewing the goals of short, medium and long term. In the case described, the results are very good in terms of strengthening the basic skills of the students involved, who undoubtedly after this experience can be incorporated more easily to other educational experiences where they could keep on working on the development of their skills to become autonomous learners. Undoubtedly, in some cases it is better to take two steps back to gain impulse and then grow faster.

References

[1] BIGGS, John (2005). *Calidad del aprendizaje universitario*. Madrid: Narcea S. A. de ediciones.

[2] MARGETSON, Don (1997). “Why is problem-based learning a challenge?”. In: BOUD, David and Grahame FELETTI (eds.). *The challenge of problem-based learning (2a Ed.)*. Londres: Kogan Page Limited, pp. 36-44.

[3] ENGEL, Charles (1997). “Not just a method but a way of learning”. In: BOUD, David y Grahame FELETTI (eds.). *The challenge of problem-based learning* (2a ed.). London: Kogan Page Limited, pp. 17-27.

[4] HUNG, Woei (2006).“The 3C3R model: a conceptual framework for designing problems in PBL”. Interdisciplinary Journal of Problem-based Learning. Vol. 1, n° 1, pp. 55-77. URL: http://dx.doi.org/10.7771/1541-5015.1006

[5] ETHERINGTON, Matthew (2011). “Investigative primary science: a problem-based learning approach”. Australian Journal of Teacher Education. Vol. 36, n° 9, pp. 35-57.

[6] NEVILLE, Alan (1999). "The problem-based learning tutor: teacher? facilitator? evaluator?" Medical Teacher. Vol. 21, n° 4, pp. 393-401.
[7] HMELO-SILVER, Cindy y Howard BARROWS (2006). "Goals and strategies of a problem-based learning facilitator". The Interdisciplinary Journal of Problem-based Learning. Vol. 1, n° 1, pp. 21-39.
[8] SUGRUE, Brenda (1994). Specifications for the design of problem-solving assessments in science: project 2.1 designs for assessing individual and group problem-solving (CSE Tech. Rep. N° 387). Los Angeles: National Center for Research on Evaluation, Standards, and Student Testing.
[9] SUGRUE, Brenda (1995). "A theory-based framework for assessing domain-specific problem solving ability". Educational Measurement: Issues and Practice. Vol. 14, n° 3, pp. 29-36.
[10] MORALES BUENO, Patricia (2014). "Assessment of achievement in problem-solving skills in a General Chemistry course". Journal of Technology and Science Education (JOTSE), Vol. 4, n° 4, pp. 260-269.