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Combining a Problem Based Learning Education and the Bloom's Taxonomy: a Preliminary Consideration

Frederic Andres, *Member, IEEE*, Oscar Salviano Silva Filho, Rodrigo Bonacin and Florent Pasquier

Abstract—The article discusses how Bloom's Cognitive Domain Taxonomy can be used to review the adequacy between University Course Curriculum on specific domains (e.g. Administration) and the Brazilian ENADE Exam. The application of Bloom's Taxonomy and its intrinsic goals combined to the Problem based Learning method (PBL) in higher education and more specifically in administration courses is interesting for the learning development of students. Such an approach will facilitate the teachers in preparing their learning material and assessments.

Keywords—Pedagogy, Bloom's Taxonomy, Problem based learning, Cognitive domain, Logistics, Supply chain, Administration



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1 INTRODUCTION

The aim of this research is to review how universities teachers (e.g. professors, lecturers) enhance pedagogically their courses and exam questions with educational objectives and hence develop courses based on higher cognitive levels to increase the overall learning outcomes[1] in Brazil. The Brazilian Exame Nacional de Desempenho de Estudantes - ENADE has been aiming to improve the course curriculum of universities (e.g. PUC, UNICAMP) by following Bloom's Taxonomy of the Cognitive Domain to define the exam educational objectives. As direct consequence of ENADE Exam, Blooms Taxonomy on the cognitive levels has been used to fix the educational objectives of university courses. This paper studies how the courses have been enhanced by meeting the ENADE Exam standard according to the Bloom's Taxonomy of the Cognitive Domain. Teachers are requested to design their courses with learning objectives that are consistent with the aim of the ENADE Exam. We would like to study how educational objectives have been combined with advanced pedagogical methods. It is important to plan for learning objectives that require training students on higher order thinking skills according to the specific exam target. This enables the university teachers to write exam questions, which represent higher cognitive levels and to develop the target skills of the students. This is reflected in students results that will logically give a realistic reflection to what they have already learned and what they should be able to do to pass the ENADE Exam and to use their new cognitive skills during their career. The paper is organized as follows. Section 2 reviews the pedagogical objectives of the teaching-Learning process of a course. Section 3 describes the community of students for this pedagogical study. We analyse the ENADE Exam and its preparation in section 4. Our usecase study combines PBL to the Learning Objectives of Bloom's Taxonomy to prepare ENADE Exam. Section 5 concludes the paper and introduces the future development of this research work.

2 PEDAGOGICAL OBJECTIVES OF THE TEACHING-LEARNING PROCESS OF A COURSE

During the creation of a course and its teaching-learning process, two major dimensions have to be defined and formulated clearly to the learners: (1) the educational objectives and (2) the pedagogical method to address the requirements of these educational objectives. In the following, we review the Taxonomy of Bloom which is a pedagogical model enabling the definition of course educational objectives and the different levels of knowledge acquisitions.

2.1 Educational Objectives

Benjamin S. Bloom [4] and other educators [2] have built a classification of educational goals for three domains: cognitive, affective and psychomotor. The main idea of the taxonomy is to propose a classification of the different learning objectives that educators set for students. The learning objectives are that what educators expect students to know. It enhances the student engagement on different aspects: development of the student cognitive skill, curiosity, learning based on the procedural memory.

Skills (see Figure 1) from the cognitive domain are a priority of the learning objectives in our use-case (Section 3).

In the revisited Bloom's Taxonomy [6], the dimension of Cognitive Processes covers the five categories of the original taxonomy, however renamed. The category "Knowledge" has become "Remember"; Understanding became Understanding; Synthesis became Create (and was promoted to the highest rank of the hierarchy); Application, Analysis and Evaluation have become respectively Apply, Analyze and Evaluate. Figure 1 shows the Revised Bloom's Taxonomy. Each dimension of the Cognitive Process is a learning objective. The learning objectives are ranked from a lower level (e.g. remembering) of complexity to higher level (e.g. Creating). The learning objectives are understood to be successive, so that a level needs to be mastered before the next level is achieved in [6].

In addition, each of the learning objective (see Figure 2) is associated with a set of actions (Verbs) that aid in classifying these learning objectives.

Once the learning objectives of a course are defined using the list of action verbs from the Bloom's Taxonomy, it is important to associate a pedagogical method to this course. In the following subsection, we review the Problem-based Learning approach, which is our target pedagogical method.

2.2 The Problem-based Learning Approach

The Problem-based Learning method created by Howard Barrows [3] is a pedagogy in which students learn about a subject through the experience of creating a problem. Figure 3 points out the major learning evolutions from the traditional learning process: (1) The professor becomes a facilitator or a coach guiding the students rather than teaching; (2) Student Centered Learning; (3) Student learning process is done in small groups of 6-10 students; (4) A Problem is the focus of the student group, and stimulates the theoretical learning process; (5) The problem is the trigger to experience the development of problem solving skills; It stimulates the cognitive process; and (6) Each student collects the new knowledge a self-directed learning process.

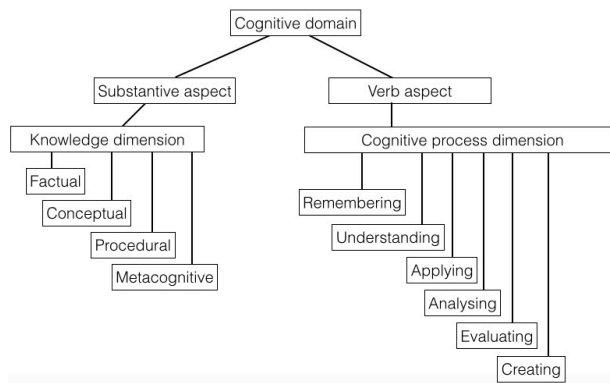


Fig. 1. Revised Bloom's Taxonomy

1-Remember	2-Understand	3-Apply	4-Analyze	5-Evaluate	6-Create
Recognize	Interpret	Run	Differentiate	Check	Generate
Remember	Exemplify	Implement	Organize	Criticize	Plan
List	Sort	Computing	Assign	Judge	Produce
Name	Summarize	Solve	Compare	Recommend	Create
Set	Infer	Demonstrate	Contrast	Justify	Invent
Write	Compare	Use	Separate	Appreciate	Develop
Indicate	Explain	Build	Categorize	Ponder	Draw Assume

Fig. 2. Bloom's Taxonomy Action Verbs

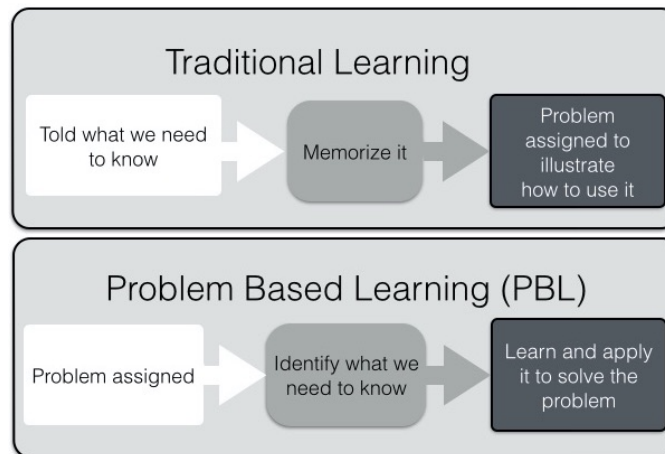


Fig. 3. From Traditional Learning to Problem-based Learning Approach

3 TARGET STUDENT COMMUNITY FOR THE PEDAGOGICAL STUDY

3.1 Background

In this study, our target community of students is part of the CEA-PUC Center for Economics and Administration of Pontifcia Universidade Catlica de Campinas (PUC-Campinas). The Center encompasses three main areas: Business Management (Administration), Economics and Accounting. The Business Management area can be decomposed in

three courses: (1) one Administration course; (2) one Administration course with emphasis on Foreign Trade; and (3) one Administration course with emphasis on "Logistics and Service". The Administration course is the most requested by students and therefore has the most inscriptions (enrolling). All courses are recognized by the Ministry of Education and Culture (MEC). Courses have a last of 3011 hours per class (8 semesters).

3.2 Courses Goal of Administration with emphasis on Logistics and Service

The objective of the course is to professionalize the student for the development of specific activities in logistics and service sectors within management area. The course also leads the students to exercise all elements that take part in the systemic view of these administrative sectors. The development of critical thinking from active teaching-learning methodology based on Problem-Based Learning (PBL) has been organised in this course. The PBL methodology has been applied since classes started in 2008. Students have been in charge for their all knowledge. Their official teacher is an advisor to help them to research and develop innovative solutions for the problems that they formulate by themselves. This pedagogical experience is really innovative, and it is motivating and integrating students around the administrative knowledge. Therefore it gives the students a competitive advantage to be exploited in the job market after their graduation. The resources used by the students are: (1) the Library, (2) the Computer Laboratory and (3) the Experiential Space Management.

3.3 Graduate's Profile

The graduate's profile of CEA-PUC can be described as follows:

- Multipurpose Specialist and Humanist Entrepreneur.
- Humanistic education and comprehensive approach which enables the student to understand and to assume a key role in the social economic, political and cultural reality, taking into consideration the principles such as social responsibility, fairness and professional ethics.
- Technical and scientific training that enables the students to have a critical view in the administration of the organizations, and in the development of specific activities related to professional practices and abilities to work in multidisciplinary teams.

3.4 Curriculum Matrix

The disciplines, which compose the curriculum matrix of the Business Management course in Logistics and Service, follow basically the disciplines of the course of Management (see Annex A), but focused in Logistics and Services issues. So, we have additional disciplines such as Introduction to Logistics and Service Management, Business Logistics, Supply Chain Management, Decision Making I and II.

3.5 Usecase: the Supply Chain Management Discipline

The syllabus of the course logistics and service ¹, in relation to the Supply Chain Management discipline, has been basically: (1) presenting the environmental factors and the main Brazilian production chains; (2) introducing concepts and management practices that integrate supply chains; and (3) emphasizing the importance of cooperation through the exchange of information within the supply chain value. Regarding the content of the discipline of Supply Chain Management, the focus has been mainly on the three following main themes: (1) The Supply Chain Network as integrated business; (2) Synchronization and collaboration in Supply Chain; and (3) Logistics in the supply chain.

3.6 Supply Chain Management Discipline via PBL Approach

At PUC-Campinas, the main objective of the discipline Supply Chain Management is to provide students with a systemic view of an organizational environment that is constituted by the link of several companies, which have common and sometimes conflicting goals such as maximizing the profitability of the supply chain as a whole at the same time looking for trying to satisfy customers in all their interests dimensions. The Supply Chain Management discipline requires knowledge of different areas, which means it is a multidisciplinary discipline that involves different topics studied over a regular course of Administration. In fact, according to [7] there are twelve themes that should be essentially contained in learning a discipline such as Supply Chain. These themes are illustrated in Table 1.

From the conceptual scope of the themes listed above, we can conclude that they are part of the contents of a postgraduate course in Supply Chain Management. However, in a regular undergraduate Administration course, these themes can also be applied. As we told before, the Business Management course at PUC -Campinas deals

1. www.puc-campinas.edu.br/graduacao/cursos/administracao-logistica-e-servicos/ementario/

1. Localization	2. Logistics
3. Marketing and redesign of supply chain	4. Inventory and forecasting
5. Supply management	6. Information technology
7. Design and launched of new products	8. Aftermarket service
9. Reverse logistics and Green Management	10. Performance measures and metrics
11. Alliances and outsourcing strategies	12. Global issues

TABLE 1
Themes of Administration with Impact to Supply Chain Management

with three different profiles of Administrative professional: one focus on foreign trade, other in logistics and services and the third in production and planning administration. Thus, the team of teachers that manage the supply chain discipline should be aware about such profiles when they develop the PBL cases. They definitely must consider themes described in Table 1. For example, if the discipline is focused on the logistics and service area, themes characterized as 1, 2, 6, 8, 9 and 10 should be taken in to account. Since 2009, the PBL pedagogy approach has been applied to Business Management course at PUC-Campinas. In parallel, the supply chain management discipline was introduced in the fourth semester of the course. Note that this brought a rethinking of the application of discipline, since the students were not yet mature enough to deal with problems related to a multidisciplinary approach of Administration area. Instead of considering this a great drawback, we identify a great opportunities to introduce students to begin to think about different concepts of administration. Thus, we consider this discipline as an open door of knowledge to introduce students with a list of challenges from Administration, which they did not have any contact before.

For better understanding, consider a problem situation where the student is faced with a phenomenon called the bullwhip effect. The students team discovers after searching in books and papers from literature what is the significance of this phenomenon. During the identification of this phenomenon, students work conceptually issues related to: physical inventory, general costs and competitive performance of supply chains. As a result, many questions are raised by the different teams of students, such as how to calculate the inventory parameters, like, for instance, safety stock taking into account demand forecasting and risk of transport. During his synthesis lecture, teacher discusses all these issues and point out the solution ways. However, he warns the class that these best management practices will be worked on in depth during other discipline of the course. For instance, inventory control is an issue to be discussed in deeply during Material Resource Management discipline.

At last, it is worth highlighting some important points of the syllabus of the Supply Chain Management discipline; they are:

- Three to four problem situations are applied. The themes encompass topics listed in Table 1;
- The assessment of each student takes into account the score provided by the sum of points obtained by the student throughout all PBL activities, which considers: student participation in all meetings, partial and final reports, presentations, self-assessments and a final examination that considers all content that was studied; and
- A set of updated books are available in the PUC library so students can use in their research. Students search for scientific papers in specialized sites provide by PUC and other Brazilian Institutions such as CAPES and IBICT. It is noteworthy that students also receive from the tutor, a plan of discipline, which contains the schedule of the discipline with the objectives and guidelines for all activities throughout the semester.

4 COMBINING PBL TO THE LEARNING OBJECTIVES OF BLOOM'S TAXONOMY TO PREPARE ENADE EXAM

4.1 The ENADE Exam

The ENADE (National Examination of Student Performance) is used by the Ministry of Education and Culture (MEC) of Brazil to evaluate the performance of students of undergraduate courses offered by public and private education institutions (colleges). Part of ENADE Exam is also used in the composition criteria for evaluating the courses of these institutions. The ENADE Exam consists of 40 questions (objectives and essay questions), which are divided into two areas: one area deals with general education issues (usually 10 questions) and the other with specific components of the course (30 questions). In both areas there are objectives and discursive types of questions. These issues are defined directly by ministerial (MEC) ordinance. There are area committees that are appointed by the MEC for preparing the questions of the ENADE Exam. The ENADE Exam occurs every year, however, its application is segmented by areas of knowledge (i.e., Engineering, Biology, Chemistry, Medicine, Management, etc). Each specific area of courses

Type of questions	2006	2009	2012
Single answer	5	5	1
Multiple answer	6	5	4
Incomplete Affirmation	2	3	0
Association	0	0	1
Interpretation	3	4	4
Assertion and Reason	5	5	1
Pictorial	4	2	1

TABLE 2
Type of questions and frequencies appeared at ENADE Exam (2006-2012)

Bloom's Taxonomy	2006	2009	2012
Knowledge	6	2	0
Comprehension	4	3	0
Application	6	13	14
Synthesis	0	1	0
Evaluation	3	4	12

TABLE 3
Frequency of questions at ENADE Exam based on the Taxonomy of Bloom (2006-2012)

is evaluated once every 3 years. PUC is a large university and has almost all areas of knowledge cited above, which means that every year there is one ENADE evaluation in one or another area. PUC usually provides to students a manual about ENADE to help them to understand the exam process. Usually, students are trained by the teachers from different disciplines of the course before participating in the ENADE Exam. The topics that will be explored during the ENADE Exam are not disclosed before the exam. Such an information is not provided by MEC.

4.2 Types of Questions that appear at ENADE Exam

The types of questions that follow Bloom's hierarchy, can be divided as follows:

- Single Answer: A single answer fully correct, alternative among others incorrect.
- Multiple Answers: Multiple correct alternatives and associated to determine a code, pointing all the right alternatives.
- Incomplete Affirmation: The introductory part of the item is a statement and not a question.
- Association: It requires two or more types of data or information that may be related.
- Gap: One or more relevant parts of the statement are deleted and present in the alternatives
- Interpretation: The question is based on literary or scientific text, tables, charts, graphs, diagrams.
- Assertiveness and reason: Two statements (correct or incorrect) and the second reason is shown first.
- Pictorial: It is based on illustrations, may be the very illustration of the problem, or used as the idea communication tool.

4.3 ENADE Exam Applied to Business Management Course

The ENADE Exam related to Administration was organised in 2006, 2009, 2012 and there will be one again at the end of 2015 (once every three years). The Business management themes that appeared in the past ENADE Exams from 2006 to 2012 were: Human Resources, Market and marketing, Theories of management and organizations, Information systems, Materials management. Other less explored themes were supply chains, logistics and decision making. In 2015, we will have the 4th ENADE Exam for the Business Management Course.

It is worth mentioning that the Business Management course which emphasizes to "Foreign Trade" and "Logistics and Service" are not explicitly considered in the ENADE Exam. In other words, what is measured is actually the performance of the student as a manager. Below, we include an analytical summary [5] of the examinations of ENADE applied to the course of Business Management and we report the frequency of each question that occurred kinds of evidential issues described in subsection 4.2 above (see Table 2) and the levels of Bloom's hierarchy described in Figure 1 in subsection 2.1.

It is possible to observe that the level of complexity increased each year. The 2012 ENADE Exam requested a more elaborate cognitive process from the students. Finally, the students got the lowest performance at the 2012 ENADE Exam (e.g. overall average of only 40% of correct answers for each question).

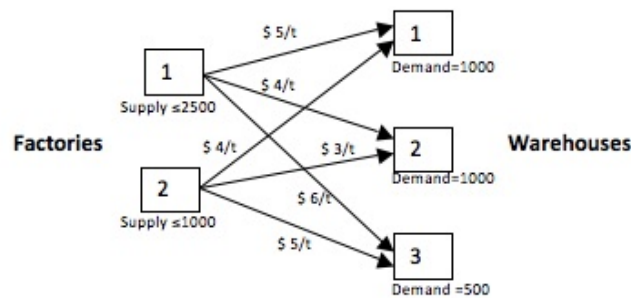


Fig. 4. ENADE Case Example

4.4 Example of a Type of Question of Logistics extracted from ENADE Exam

We introduce an example of questions that combines at least two types of question (Table 2): multiple answers, and pictorial interpretation. It also involves the pedagogical objectives knowledge, analysis and synthesis from the Bloom's Taxonomy (Table 3).

Analyze the following case (see Figure 4):

The supply chain of the Plant Products Company - CVP - has two factories that supply three warehouses. Factories have a maximum level of production based on their size and the anticipated yields. Costs in \$/t are noted for each route (link between factories and warehouses). José Almeida, student of Business Management school, was hired by the Department of Logistics and Supply Chain in order to meet the demand of deposits without exceeding the capacity of the plants, minimizing the total cost of transport as well. In his decision, he considered the following situations:

- I. 1,000 units must be transported to the Factory 2 for warehouse 1. The remaining demand must be supplied from the Factory 1;
- II. 2,500 units must be transported to the Factory 1 for warehouse 1 and 2. The remaining demand should be supplied from the Factory 2;
- III. 1,000 units must be transported to the Factory 2 for the warehouse 2. The remaining demand must be supplied from the Factory 1.

The alternative below that gives the lowest cost is

- (A) I. (B) II. (C) III. (D) I and III. (E) II and III.

5 CONCLUSION AND FURTHER DEVELOPMENT

In the quest to enhance the pedagogical quality of student experience during their university studies and to prepare them to the Brazilian ENADE national exam in Brazil, courses combine multiple pedagogical elements which engage the student learning process during a course. This paper reviews how the educational objectives and Problem based Learning (PBL) method have been combined in order to increase the pedagogical quality of student experience during their studies on administration at CEA-PUC. PBL is a pedagogy method that makes the Bloom's approach more strong. In fact, with PBL the student is challenged along the time to use his brain to find his own solution for problem proposed, while in the traditional lecture way of learning, teachers show the way. In this case, if you have a good memory you are considered the best student in the class. The Bloom's Taxonomy goes beyond the memory of knowledge provided by teachers. In our opinion, it asks for analysis and interpretation of the student. Thus, in my conclusion, PBL is an important allied of the Bloom approach. In the next coming months, we will focus on a new metric: the Pedagogical Cognitive Domain Quality (PCDQ) metric. We will develop two ontologies: one related to the CEA-PUC courses, (usecase for our research) and one related to ENADE exam. Our focus is to summarize the PCDQ consistency of the CEA-PUC course descriptions with the body of knowledge of the ENADE Exam.

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APPENDIX

MATRIX CURRICULUM FOR ADMINISTRATION COURSE WITH EMPHASIS ON LOGISTICS AND SERVICES

Semester	Disciplines	Hour Load
1	Theological anthropology A	34
	Ethics and social responsibility in companies	68
	Philosophy	34
	Student integration in university life	17
	Introduction to management of logistics and services	68
	Financial mathematics	68
	Mathematics for administration	68
	Program learning community	17
2	Administration of information management	68
	Accounting for administration	68
	Process education/ Training in learning path	17
	General theory of administration I	68
	General theory of administration II	68
3	General theory of administration III	68
	Human resources management I	68
	Human resources management II	68
	Human resources management III	68
	Social sciences	34
4	Statistics for administration	68
	Economy A	68
	Economy B	68
	Brazilian economy and sectoral analysis	68
	Education for human rights and cultural identity	34
	Project management	68
	Administration Decision making I	68
5	Supply chain management	68
	Financial and budget management	68
	Financial management I	68
	Autonomous activities of professional practice I	68
	Corporate accounting	34
	Cost management	68
	Professional practice and course work I	34
6	Production management I	68
	Marketing management I	68
	Marketing management II	68
	Management in virtual environments	68
	Theological anthropology B	34
	Autonomous activities of professional practice II	68
	PF-practice of training A	17
	Professional practice and course work II	34
7	Production management II	68
	Management of service operations	68
	Material management	68
	Autonomous activities of professional practice III	85
	Tax management	34
	PF-practice of training B	17
	Professional practice and course work III	34
8	Administration decision making II	68
	Strategy management	68
	Theological Anthropology C	34
	Autonomous activities of professional practices IV	85
	Additional training activities	306
	Management of quality and projectivity	68
	Business logistics	68
	Service marketing	68
	PF-practice of training C	17
	Professional practice and course work IV	34

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