

# Case Study Approach in Engineering Classes: Methodologies, Strategies and Recommendations for Teachers and Students – insights from the case “Banco da Amazônia”

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## Abstract

Case studies allow readers to have contact with real life business, management or engineering situations, among others. They can be designed with learning objectives in mind. Case studies has become the main teaching method in the most of business schools since the pioneer example of Harvard University. Nevertheless, they represent an important teaching method in other areas namely, in the engineering context. The case study teaching method implies a process of analysis and discussion lead by well-prepared case teachers, which should follow appropriated strategies in order to maximize the results. This paper presents the case study approach as a teaching tool and discusses it in practice through a case study designed by the authors. The case “Banco da Amazônia” is a case on investment appraisal and risk evaluation designed for engineering students. For this purpose, the process of design and implementation of the case “Banco da Amazônia” is explained in detail. Recommendations for both teachers and students are presented and discussed. As a result, several methodologies and strategies are provided.

Keywords: Case Study; Teaching Methodologies; Investment Appraisal; Risk Analysis; “Banco da Amazônia”.

## 1 Introduction

Exact sciences programmes in Brazil normally split the different areas of knowledge in different departments. This process promotes a segmentation of the education process and, consequently, the knowledge becomes a set of disconnected information, which does not contribute to the process of teaching and learning (Nascimento Pinto, 2002).

With the specialization of the engineering programmes and new methodological approaches to teaching, their curricula had to improve. Nowadays, the focus is on the students who must develop, beyond the basic technical knowledge of their area of expertise, other skills and competencies as teamwork, leadership, communication, initiative, auto-didacticism, adaptability, effectiveness, professionalism, management capacity and cognitive skills (Costa et al., 2010). Engineering education must be based on methodologies and strategies that consider the new challenges of the modern engineer, which must meet the demands of the market, as well as a dynamic and entrepreneurial profile to act on problems whose solutions are based on analyses of real problems, such as projects that need to be analyzed and evaluated.

For many teachers and students, the case teaching method is the most effective and gratifying approach to teach and learn. It is an approach followed by a countless number of teachers in several areas and it is the main teaching method in some world class schools. In general, case studies present a problem characterized by several alternative solutions and some uncertainty or ambiguity in terms of outcome. This is important because, as a teaching method, a case study is an instrument not an end. Students should interpret the problem much more than reach a (possible) solution. Commonly, before publication, case studies designed for teaching purposes are refined and tested in the classroom by the authors. Most times they are complemented with additional relevant documentation and readings, teaching notes and instructions.

This article presents the approach of case study as a teaching tool and discusses this method through a case developed by the authors. In this sense, a case study of “Banco da Amazônia” (Bank of Amazon) was organized. The case is based on the strategies and tools that the bank used to assess relevant risks to an investment

project that was sent to fundraising by the FNO (“Fundo Constitucional de Financiamento do Norte”, Constitutional Financing Fund of the North) program in one of the States belonging to the north region of Brazil, in 2011.

The case teaching method assumes that both the teacher and the student contribute to the learning process. Although the professor is more familiar with the material of the case than the students, his knowledge is not regarded as final, because the participants bring new insights and perspectives on the issues addressed. Case studies require that students learn in a way that might not be familiar. Instead of passively receiving information, students become active participants in the learning process. For the assessment of risks in investment projects, which presents some complexity, it is essential to identify, assess and manage the different types of risks. The case teaching method applied to this type of problems would be of great use to students who might in the future be in the role of elaborating investment projects, deciding on funding or even investing on them.

This paper reports the experience of the application of the case teaching method in a class of the Production Engineering programme at *Fundação Universidade Federal de Rondônia*, with the students enrolled in Economic Engineering which is a course of the 8th semester. Students felt gratified by what they considered to be a new methodology of learning. For this reason, the first task of the teacher was to explain the case-based learning methodology as an active teaching methodology that explores specific and realistic situations, allowing arrive to different conclusions, depending on how the learning process occurs.

## 2 Literature Review

### 2.1 The Case Study Method

The case study method offers significant opportunities for students to put themselves in the position of administrators, managers, engineers and other professionals involved with the world of business, and may enable the study of several problems of management, production and logistics, which would be difficult for other methods. The scenarios can be studied and tested in a controlled environment without the constraints of the real life context. Case studies are suitable for studying contemporary events, in situations where the relevant behaviours cannot be handled, but where it is possible to make direct observations and systematic interviews. Although it has points in common with the historical or archival method, the case study method is characterized by the ability to handle a full range of evidence-documents, artefacts, interviews and observations (Yin, 1989).

The case study method, as other methods, has its advantages and disadvantages that should be analysed in the light of the type of problem and questions to be answered. As advantages we can point out the researcher control of actual behaviour events and the focus on the present. Some of the main disadvantages are the difficult to prepare case studies and the fact that the results obtained cannot be generalised to the wider population. Yin (1989) presents four applications for the case study method:

- a) To explain causal connections in real-life interventions that are too complex to be addressed by surveys or experimental strategies;
- b) To describe the intervention and the real-life context in which it occurred;
- c) To illustrate some topics within and evaluation, albeit in a descriptive mode;
- d) To explore those situations where interventions have no specific results.

As Graham (2010) refers, the case study methodology results in new relationships between the teacher and the students. The student is challenged to assume an analytical and decision-making position. The theory and understanding comes from problem solving or analysis of a number of measures to be taken. Both the teacher and students assume the responsibility for learning process: the knowledge and ideas are passed from the teacher to the students, from the students to the teacher and between students. The teacher becomes the

guide of the process and not the source of the solution. For some, that is a challenge. To work with the case study methodology, a change of approach is needed.

Based on this understanding, Graham (2010) and Nascimento Pinto (2002) point out that with the fragmentation of knowledge, new methodologies of learning became an object of study and research for many educational institutions around the world. Educators are concerned with the traditional model because they realize that students are passive agents of the teaching-learning process and the retention of knowledge is low. Thus, various proposals for innovative teaching and learning models have appeared over the years.

## 2.2 Teaching Methods

Some procedures and practices in engineering education are described as reference to the pedagogical design used in engineering programmes over the last few decades:

- a) *Discovery Learning*: is an innovative teaching methodology whose principle focuses on encouraging students to seek answers and paths related to problems previously supplied. In this approach, students receive data, issues or problems for which they must discover their possible answers and solutions, acquiring and aligning the conceptual learning to practice during this process (Bruner, 1961). According to Singer and Pease (1978), the effectiveness of discovery learning methodology is superior to that of the traditional learning methods when the knowledge is obtained through the development of skills already belonging to the student profile.
- b) *Inquiry Learning*: constructivist methodology of active learning where curiosity is the driving engine of learning. Banchi and Bell (2008) describe four levels of this methodology: 1. Confirmation inquiry - indicated to reaffirm previously discussed content, to stimulate the student to learn how to search for new data and how to do research; 2. Structured inquiry - structured-questions and procedures are still provided, however, the answer is not known, students must generate a hypothesis informed by research conducted; 3. Guided inquiry - professor provides the questions and students must develop, in addition to the data collection and development of hypothesis, the testing method and the explanation of the results obtained. Finally, level 4 – Open inquiry - students must act as researchers developing questions, seeking information, obtaining data, raising hypotheses and defending them.
- c) *Case-Based Learning and Just-in-Time Teaching (JiTT)*: use of complex problems, based on facts and written in such a way as to stimulate students to classroom discussion and collaborative analysis. Case-Based Learning (CBL) is an active teaching methodology which explores realistic and specific situations, where students may reach different conclusions. Just-in-Time Teaching (JiTT) is a teaching and learning strategy based on the interaction between an active learning process and studying activities based on (Novak and Middendorf, 2004).
- d) *Collaborative Learning*: active teaching methodology where students are arranged into groups to work on the same problem. Despite the difference between the students may seem an obstacle, it is precisely the enriching factor, since the clash of perceptions will enrich the content of the group conversations. Another factor which helps in this type of learning is the intervention of the teacher, guiding the group, when he/she notices dispersion in the team (Smith and MacGregor, 1992).
- e) *Cooperative Learning*: is similar to collaborative learning. The difference is only in the distribution of students' roles: collaborative learning can assign the same task to a small group of students or to the entire group, while in cooperative learning a different role is given to each participant (Chiu, 2004).
- f) *Project-Led Education (PLE)*: active teaching methodology that can occur on three levels, depending on the degree of substitution of the traditional teaching materials: level 1 - consists of applying knowledge and techniques previously known to an issue and is commonly applied in parallel to a course of traditional teaching; level 2 - is close to level 1, but is interdisciplinary, occurring in parallel to several matters. In level 3 - project approach overrides the materials as a whole in the composition of the course (Helle et al., 2006).
- g) *Problem-Based Learning (PBL)*: teaching methodology in which students learn about a particular subject based on solving complex, multidimensional and realistic problems. It is centred on two basic points of the cognitive theory: work on important or significant issues, and search for more information when presented with an unknown situation (Ausubel et al., 1980). From this perspective, feedback and

reflection on the learning process and group dynamics are essential components of problem-based learning (Hmelo-Silver, 2004; Hmelo-Silver and Evensen, 2000). It is believed that the resolution of practical cases or real problems facilitates the learning process, because they allow to show to students how important the theoretical content is as well as motivate them to work as a team and develop their own style for problem solving (Barrett, 2010; Barrows, 1996).

- h) *Project-Based Learning (PJBL)*: promotes learning through students' participation in project teams. The projects developed by the students involve the resolution of complex problems of the real world and usually vary on the level of complexity and comprehensiveness. The projects involve students in design activities, problem-solving, decision-making, research activities and teamwork. Oliveira et al. (1998) consider the activity of problem design as a fundamental activity for engineering students. They should integrate into each new project their knowledge and experiences in an attempt to identify, prioritize, and fix problems. Such a process takes place through two steps: the synthesis and analysis that occur alternately during the conscious development of the project.

### 3 The "Banco da Amazônia"

The mission of "Banco da Amazônia" is "to create solutions for the Amazon region to reach unprecedented levels of sustainable development through conscious entrepreneurship" (BRASIL, 2013). This region has extensive incentives for economic development and sustainable growth through numerous funding programs released by the federal government. The contribution comes through financing the implementation, expansion, modernization, renovation, relocation of firms, etc., through fixed and/or semi-fixed investment and joint investment projects.

The present case study addressed relevant criteria of the Financing Program of the Constitutional Financing Fund of the North (FNO – "Fundo Constitucional de Financiamento do Norte") which is considered the most comprehensive public financing fund in the region, allocating financial resources for individual people (e.g. farmers), individual companies, associations of companies and cooperatives organized under Brazilian law (BRASIL, 2013). Based on estimations of FNO about the resources which were allocated to the Amazon region in the year 2013, among other results, more than 52,000 beneficiaries/projects were supported, and more than 560,000 new job opportunities were created, gross regional product increased more than R\$ 17,600 million, the rural exodus registered a reduction, intra and inter-regional disparities were minimized, social inclusion registered improvements and poverty a reduction, as well as the increasing in regional Gross Domestic Product (GDP) and tax collection.

To have a better and systematic overview of the case study, it was decided to select a particular state from the several states of the Amazon region. The selected state was Rondônia. Table 1 shows the evolution of FNO resources allocated to this state between the years 2011-2013.

Table 1: The evolution of FNO resources allocated to this state between the years 2011-2013

PERIOD	2011	2012	2013
Funding	R\$ Millions		
	589.130	683.400	790.000
	Beneficiaries/Projects		
	8.247	9.566	7.784
Socio-economic benefits	Job Oportunities		
	72.384	83.967	76.630
	GDP R\$ Millions		
	2.020,0	2.343,2	3.496,5

Source: "Banco da Amazônia" (2013).

These funds are intended to finance the construction, expansion, modernization, renovation, relocation of projects through fixed and/or semi-fixed investment and joint investment from which the release occurs through funding projects designed by professionals.

To perform the risk analysis, the institution has the contribution of credit raters who use several indicators of risk assessment and have a central role in the decision making process from which projects are approved or

rejected. In this context, risk assessment in investment projects is of significant importance and is very complex. Know, evaluate and understand how to manage different types of risks is essential both for those who will be in charge of the investment project and for financing institutions and investors. The case study focuses on these issues.

## 4 Case Design and Implementation

The case study was prepared for an audience of engineering students. The test case was done with 39 industrial engineering students of the course of engineering economics. With the application of this case, students had the opportunity to verify the importance and the applicability of concepts and techniques which have been taught during the classes.

The application of the case teaching method implies that students have already some understanding of basic principles which are needed to develop the case. In this case study, students should be prepared with the basics of investment appraisal and risk analysis concepts and techniques. Investment evaluation methods range from "common sense rules" to very sophisticated mathematical models. In particular, students must be familiar with Net Present Value, the Annualized Value and the Internal Rate of Return.

The implementation of the case began with a preparatory class prior to the delivery of the case study to students. In this lesson, some characteristics of the financial institution ("Banco da Amazônia") are addressed and discussed. This institution is responsible for the distribution of FNO program resources in the Amazon region, as well as the specific strategies that are used by the evaluators for the approval and/or rejection of the release of funds for the project. In this preceding class, teachers can present and discuss the case study in general terms. In this particular case, it is important to contextualize investment policy and strategies for the Amazon region, specifically the characteristics of federal programs, the type and amount of available financial resources, the characteristics of the Rondonia state, the role of "Banco da Amazônia", tools and practices in terms of risk analysis in project appraisal, among other issues.

After the class preparation, the case study was delivered to students. The first task was asking them to identify which contents already studied in the course of engineering economics will be useful to understand the case study. Additionally, students were motivated to know more about financial programs of the federal government, including those related with the "Banco da Amazônia". Students had a period of 10 days to present the results. They were challenged to make suggestions for the improvement of the performance of the professionals responsible for the preparation of projects related with the FNO program submitted for funding to the "Banco da Amazônia".

The case study was designed in order to prepare students to be able to understand and reflect about managing processes in real contexts, stimulating discussions and reflections about specific technical knowledge and more general skills related with management functions and decision making. The case study was designed to challenge students to organize themselves in the preparatory work, through the organization of teams after reading the case. In the application of the case study, students were organized in five teams. Each team was responsible for the contextualization of a specific content covered in the case study and in the end they would be able to respond to a check list (explained in next section). Particularly, which tools and why they should be used by the professionals who prepare projects for the FNO program.

Therefore, the time span for the discussion of the several issues presented and the preparation of the answers and proposals was 10 days. Teams would meet on three specific occasions to assess and decide the best strategies. Teams must support the analysis and proposals on bibliographic material, articles, information published in websites and information of "Banco da Amazônia". The evaluation of students work was based on the appropriate use of the concepts and tools learned in the course of engineering economics, the communication skills of the team and the final results presented.

## 5 Writing the Case

Nowadays, markets are characterized by a high and increasing volatility and competition and investment and business models tend to be more complex and innovative than in the past. In this context, investment appraisal in general and risk assessment in particular assume new levels of importance and complexity. In this context, the evaluation and the understating how to manage different types of risks is essential both for those who develop investment projects and for investors.

Funds provided by FNO have been contributing to the generation of new employment opportunities of skilled labor, the increasing of regional GDP, the continuous reduction of rural exodus and poverty, social inclusion, the minimization of intra and inter-regional disparities, increasing of wages and tax revenues. As a financial institution, the "Banco da Amazônia" is under the supervision and regulation of the Central Bank of Brazil ("Banco Central do Brasil") and the Monetary Policy Committee ("Conselho Monetário Nacional") and the Securities and Exchange Commission ("Comissão de Valores Mobiliários"). As a public company, the bank reports to the Office of the Controller General ("Controladoria Geral da União"), the Federal Court of Accounts ("Tribunal de Contas da União") besides the internal and external audit departments.

Regarding the procedures for the analysis and evaluation of projects, it was observed that analysts make a basic characterization of the project in a specific form once the project reaches the bank. Then, they observe if the project respects the relevant regulatory framework and if proponents have the necessary capacity to make the payments which will be asked by the project. On the other hand, when the bank receives proposals which present some potential risk, the project may be returned to the proponents asking them to reorganize the project in order to reduce or control such risk. If there is still some risk, the project must explain who will assume the risk (the customer, the bank or a third person).

The case study refers to a project submitted by a micro company dedicated to the production and sale of bread and other derivatives of wheat flour to the area of influence of the project. This company was founded in 2007, consisting of 2 owners, one of which owns 95% of the share considering a total capital of R\$ 40,000.00. The investment project was of R\$ 191,954.00 with the objective of capacity expansion and used resources from the FNO/Amazon Fund ("Plano Amazônia Sustentável"), with a full payment term of 144 months, a grace period of 48 months and a payment in 96 months. The warranty is a land property of the company in the amount of R\$ 100,000.00. The projected annual sales were about R\$ 340,000.00. The fixed costs summed R\$ 47,000.00 and variable costs R\$ 240,000.00.

Based on the data and information of the case study and the contents learned in classroom, the main questions are:

1. Which criteria should be used to prepare and submit projects for evaluation by the "Banco da Amazônia"?
2. Regarding the concepts of engineering economics, make an analysis of the use of the method of present value, the Internal Rate of Return and Payback time, plus the sensitivity analysis to identify the variables that most influence the viability of the project;
3. Which risk measures can be pointed out in the evaluation of the project?
4. Develop a checklist of information to be verified by the professionals who prepare investment projects for the FNO program in the state of Rondônia.

Students should consider that the bank is cautious and uses several methods to approve investment projects in order to release funds with the lowest risk.

## 6 Results and Discussion

Through the case teaching method students are challenged to develop a set of tasks and assignments which give them or consolidate specific knowledge as well as important personal skills namely planning capabilities, team work skills, etc. In this case, teachers and case study designers developed several strategies to achieve the proposed pedagogical objectives which are related with the application and understanding of concepts



and tools taught in the course of engineering economics. Students were asked to use basic principles of economics, to understand the principles of financial mathematics and to apply several methods of risk and uncertainty analysis in investment projects.

During 10 days, the class composed by 39 students of industrial engineering, has been involved with the case study. It was possible to observe that students dedicated significant effort to discuss the case during the class and even extra-class. Teams performed the 3 meetings, where each team brought to the discussion the content necessary for the final writing task. To understand the criteria used by "Banco da Amazônia" and answer to the first question, students have made a visit to the institution in the city of Cacoal. Indeed, some details are not accessible from the reports available on the bank's web page on the internet.

Regarding the tools of engineering economic, teams worked together to avoid major errors in the computation of financial ratios and project evaluation measures. Students also have been asked to identify reasons which could justify broadly the need for resources to carry out the project. On the other hand, they had some difficulties on the risk assessment, claiming that they could not see all risks that could affect the project. The inexistence or difficulties to have access to some important information for the decision making is a limitation of this teaching approach. This situation is in line with the arguments of Novak (1999) who also used an approach based on the interaction between an active learner and a set of study activities based on readings.

In this case study, the teachers who have supervised the exercise argued that the decision-makers will be able to make a better assessment of the viability of the investment projects if they support their decisions on appropriate indicators and approaches for risk analysis and management. Thus, students should base their work on the literature. Furthermore, it was observed that, as Graham (2010) states, the case teaching method approach contributes to the establishment of deeper relationships between teacher and students, particularly when students are challenged to assume a decision making perspective. Solving problems in class is not enough. Students should be able to understand problems in their context and propose solutions even considering scarce or ambiguous information.

For Barret (2010) the resolution of practical cases and/or real problems facilitates the learning process, allowing students to apply theoretical content, motivate them to work as a team, developing presenting skills and capabilities to solve problems and design solutions for proposed problems. Students considered this approach different by the fact that in other courses they just receive texts for discussion. They considered the approach innovative taken into account that they were asked to study theoretical contents and they were challenged to search for information outside the classroom and explain how to decide in a real situation.

Based on these facts, some of these methodologies could be adopted in engineering education, considering pedagogical results and feedback over the last few decades cited by Helle et al. (2006), Bruner (1961), Singer and Pease (1978), Banchi and Bell (2008), Barrett (2010), among others.

## 7 Conclusions

The case study teaching method offered significant opportunities to students, namely the involvement with the business world and the opportunity to deal with real problems. It was found that there was an involvement of the students in problem solving in the decision making activities, the motivation to seek solutions and teamwork.

The "Banco da Amazônia" is a case of investment appraisal and risk assessment, which was designed for students of production engineering. The case study allows students to be able to understand and reflect on how to make decisions and to manage in real contexts. It stimulates discussion and reflection on specific technical knowledge and skills related to more general management functions and decision making.

The case study challenge students in organizing themselves as teams. They felt motivated to learn more about the financial programs of the federal government, including those related to the "Banco da Amazônia". Students have been challenged to contribute with suggestions to improve the performance of the professionals who prepare and evaluate investment projects submitted to the bank.

The students considered the case study teaching method a very innovative approach. They were asked to study theoretical content beyond those presented in the classroom in the field of engineering economics. Thus, the learning process and outcomes were beyond those which could be achieved through the traditional classroom-centred approach. It was also found that other teachers of the Production Engineering programme are not applying this kind of learning methodologies despite they are already being used for some decades by most engineering courses.

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