Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 123 (2015) 449 – 461

Procedia Engineering

www.elsevier.com/locate/procedia

Creative Construction Conference 2015 (CCC2015)

Educational simulation in construction project financial risks management

Augustin Purnuş[a]*, Constanţa-Nicoleta Bodea[bc]

[a]Technical University of Civil Engineering, 122-124, Lacul Tei Blvd., Bucharest, Romania
[b] Bucharest University of Economic Studies, 6, Piata Romana, Bucharest, 010374. Romania
[c] Centre for Industrial and Services Economics, Romanian Academy, 13, Calea 13 Septembrie Bucharest, Romania

Abstract

Construction sector is vulnerable to economic changes, especially during recession periods due to the high capital outlays, cost flexibility and high competition limiting the price. The changes of the business environment, often associated with shortage of funds, exchange rate fluctuation and political instability increase the construction projects financial risks. In this context, the application of structured approaches related to the financial planning, scheduling and monitoring of the projects is even more important. In order to execute these processes, the project managers should have the necessary competences. The development of financial management competencies cannot be achieved into the classical educational settings, by using common methods of knowledge transfer. Instead, the project financial management should be taught in active and experiential ways, stimulating students to think creatively and to act properly as project managers. Education simulations are very valuable in this regards.
The paper presents the experience gained in the master program of Project Management in Construction held in the Technical University of Civil Engineering Bucharest. Based on the main international project management competence standards and relevant educational experiences, the authors designed a simulation platform. The paper presents the architecture and functionality of this platform. A simulation scenario is presented as a case study.

Peer-review under responsibility of the organizing committee of the Creative Construction Conference 2015

Keywords: knowledge management; educational simulation; project financial management

* Corresponding author. Tel.: +4-021-22402000; fax: +4-021-22402000.
E-mail address: purnus@utcb.ro

Peer-review under responsibility of the organizing committee of the Creative Construction Conference 2015
doi:10.1016/j.proeng.2015.10.089

1. Introduction

Financial aspects of the construction projects represented always a major challenge for any construction company, especially in changing economic settings. Due to the high project capital expenses, the low cost flexibility and the high competition limiting the final prices, the construction sector is vulnerable during recession periods, associated with shortage of funds, exchange rate fluctuation and political instability. Borghezi and Gaudenzi [1] consider that the credit interest rate, currency and liquidity to be the main factors which generate financial risks in construction projects. Hlaing et all [2] list the most relevant risk factors for the construction industry and the top four are: the lack of financial resources of the contractor, the weak financial stability of the client, the costs overruns and the contractor financial stability. Accepting too many risks, the construction companies become financially vulnerable. The lack of cash during the project implementation, at both client and contractor levels leads to delays, penalties and loss of opportunities, with a strong impact on the health of projects and organizations [3].

In 2014, KPMG [4] interviewed from more than 100 private and public organizations around the world, that carry out significant capital construction activity. The analysis followed four dimensions of the project management practices: preparation (the project planning and prioritizing and the talent management), project risk, controls and governance (project control and project management information systems), project performance (dealing with project failures and contingency planning) and leading relationships (collaboration between the owner and contractor). Regarding the project financial management, as some of the main findings, we can mention: 84% of the companies utilize financial and risk analysis to screen projects; 80% say the majority of capital projects are planned; only 31% of all respondents' projects came within 10% of budget in the past 3 years; 58% are lump sum (fixed price) contracts. The type of contract which is the base of the relationship between the parties have significant effects on the strategy the construction company will take in order to achieve it purposes in terms of cost, duration and profit. Considering the project delivery strategies, 72% of the participants hold full competitive tenders when awarding contracts. Despite some concerns about a lack of flexibility, the traditional design-bid-build approach remains one of the two most popular project delivery strategies, enabling the owner to work with various suppliers for different aspects of the project. One of the biggest concerns expressed by the survey participants is the accuracy of the estimated costs before committing to the project. The survey findings indicate that bigger organizations (which tend to have larger and more complex projects) are more likely to take a conservative view of contingency levels. Over half of the respondents from this segment report that the typical range of contingency is greater than 10 percent of the total estimated cost.

In order to manage financial project risks, most of the companies are focusing on the individual project level that does not reflect the overall risks at a corporate level. The simple sum of individual project's risks can be significantly different from the total risks of enterprise-wide perspectives [5]. The construction companies should have capital budgeting and planning policies and procedures in place, a cross-functional capital review committee, and a robust system for tracking and reporting across the portfolio. Several techniques from portfolio theory have been proposed, in order to reduce turbulent risk exposures and maximize the total value of the company [6].

According to [7], the major processes of project financial management are: the financial planning (identifying key financial issues to be addressed and assigning project roles, responsibilities and reporting relationships), financial control (monitoring key influences and taking corrective measures when negative trends are recognized) and administration and records (designing and maintaining a financial information database to enable financial control to proceed in a smooth way). Executing these processes, the project management professionals should address the associated risks, by identifying and assessing them, selecting strategies and implementing response plans.

In order to manage the project financial risks, the professionals should have the necessary competencies. The key project managers' competencies are mainly associated with hard skills (the technical methods and tools application), but soft skills (leading the people) should also be taken into consideration (such as: communication skills). The development of the project financial risk management competencies cannot be achieved into the classical educational settings, by using common methods of knowledge transfer. Instead, the project financial risks management should be taught in active and experiential ways, stimulating students to think creatively and to act properly as project managers. Education simulations are very valuable in this regards. Even if there are recommended a large number of methods and tools to be used, only few of them are regularly applied during the construction project life cycle and even fewer for managing project portfolio financial risks ([8], [9]). A very common method is project cash flow analysis [10].

The paper is structured as follows: after the introductory part (section 1), section 2 presents the main characteristics of developing the competencies for managing financial risks in construction projects. Section 3 presents a proposed simulation platform for teaching financial risk management in construction projects, based on the experience gained in the master program of Project Management in Construction held in the Technical University of Civil Engineering Bucharest. Conclusions are drawn in section 4.

2. Developing the competencies for managing project financial risks; using simulation as educational method

Project manager's education and training in the project financial risks management subject means to develop the required knowledge, skills and attitudes on project financial management, project risk management and project portfolio management. Based on [7], [11] and [12] we identify several learning topics (table 1), which should be considered when the curricula/syllabus is designed.

Table 1. Learning topics associated to the involved subjects

Project financial management	Project risk management	Project portfolio management (PoM)
Project financial management concepts (financial management vs. costs management, sources of funds, costs of project financing, funding points, project creditworthiness, cash flow measurement, net cash flow, inflow, outflow, cash flow analysis)	Risk concepts (risk probability/distribution, project risks vs. business risks exposure, impact, proximity, expected monetary value)	PoM concepts (portfolio, portfolio management, relationships among portfolios, programs, project and organisational strategy, PoM roles, POM stakeholders, PoMIS, Po governance, portfolio performance)
Main project financial management processes and interactions with other knowledge areas (costs, risks, time management)	Project risk processes (initiation, planning, executing, monitoring and controlling, closing)	Project PoM processes groups and interactions (defining, aligning and authorizing)
Project financial planning (identification of financial needs, understanding the contract requirements, estimating financing costs, establishing the financing points, sensitivity analysis, developing and testing the financial project plan, assigning responsibilities)	Risk identification (risk sources, risk breakdown structure, risk register, risk identification techniques)	PoM process implementation (assessing the current state, defining PoM vision and plan, implementing PoM processes, improving PoM processes)
Project financial control (monitoring key influences and taking corrective measures when necessary) Administration and records (designing and maintaining a financial information database)	Qualitative risk assessment (assessing the probability and impact of project risks)	Portfolio strategic management (developing portfolio strategic plan, portfolio charter, portfolio roadmap and managing strategic change)
Interpersonal skills in project financial management (involvement and influencing of others, communication)	Quantitative risk assessment (assessing the probability and impact of project risks)	Tools and techniques for PoM (for elicitation, structure analysis, component categorization, portfolio review, weighted ranking and scoring, quantitative and qualitative analysis, capability and capacity analysis, scenario analysis, value scoring and measurement analysis, benefit-realization analysis)
	Selecting strategies and implementing response plans to address project risks (risk owner, individual risk profiles, response strategy and plan, residual risks, contingency and fall back plans)	Interpersonal skills in PoM (communication)
	Interpersonal skills in project risk management (involvement and influencing of others, communication)	
	Evaluate and monitor risks, opportunities and implemented responses	

These topics are grouped into several training modules, aiming the development of the following knowledge and skills types: subject-specific skills (related to processes and methods), systemic skills (skills closing the gap between theory and practice) and generic (subject-independent) skills, such as: interpersonal and instrumental skills.

According to this typology of skills, we can identify the following four categories of modules in the courses on this subject:

- *Core modules* (groups of topics which make up the backbone of the respective subject)
- *Specialized modules* (list of topics of which participants want to understand to a larger extent). A special specialized module is the transferable skills module (e.g. work experience / practice, projects, dissertation, business games, etc.)
- *Modules on interpersonal skills*, such as: module on communication skills.
- *Support (instrumental) modules*, such as: mathematics, statistics, Information Technology (list of topics which complement those included in the core modules);

The learning outcomes are the statements of what the participants are expected to know, understand and be able to perform at the end of the course/module. The learning outcomes are defined in terms of competencies which will be developed or enhanced by the course/module. Alignment to the international/national qualification frameworks and professional standards is an important constraint in defining learning outcomes. The Biggs's constructive alignment principle [13] requires that the learning outcomes determine what teaching and assessing methods have to be applied. The different complexity of cognitive skills [14] to be developed requires different teaching approaches. Table 2 shows recommended teaching and assessing methods for the teaching the subject *Project financial risk management*.

Table 2. Recommended teaching and assessing methods for the subject Project financial risks management

Complexity of the cognitive skills (based on Bloom's taxonomy)	Recommended teaching methods	Recommended assessment methods
Lower complexity (*Remembering* and *understanding* levels in Bloom's taxonomy)	Lecture, Visuals (audio, video) presentations, Examples/illustrations, Guest Speakers, Discussion groups, Presentations writing, Assessment reports	Presentations, Participation in learning activities, Exam
Medium complexity (*Applying* and *analyzing* levels in Bloom's taxonomy)	Practice demonstrations, **Simulations,** Role play, Discussion groups, Case studies, Assessment reports, Problems, Case studies, Critiques	Presentations, Participation in learning activities, Assignments, Exam, Project reports, Group work, Essays
High complexity (*Evaluating* and *creating* levels in Bloom's taxonomy)	Practice, Problems, Case studies, Creative exercises, Brainstorming sessions, **Simulations**	Essays, Extended writing

Simulation technologies represent powerful educational tools that are becoming widely used due to their effectiveness in providing valuable learning experiences. Simulations performed during the training sessions are referred as *educational simulations*, in order to differentiate them from other simulation types, such as: experiments for decision support, entertainment and imitation [15]. Recommendations, guidelines and procedures were defined for a good educational simulations implementation. Heineke and Meile [16] consider that for simulations to be effective, they should provide an "aha" effect (the insight gained should be unknown before simulation take place); they should require students to generate date instead to receive date; they should be less stressful and use simple materials. The teacher must be very well prepared in running the simulation sessions. The teachers have to adopt a less intrusive role in student learning process, acting more as coaches, and not as instructors.

Students typically support the games and simulations usage, rating these methods quite highly in their list of preferences. Students reported that the simulations developed their abilities to solve problems systematically, perform forecasts in uncertain environments and to measure objectives. Klassen and Willoughby [17] applied two assessment instruments: before and after questionnaires and playing the game twice, to see if student performance improved the second time. The simulation games provide good learning experiences because students make decisions, and after that, they make further decisions based on the first results. The students better remembered the educational material learned from games than a classical lecture. This might be the most important reason for using games in the classroom. Besides this, the students developed positive feelings toward the course, improving the chance of paying attention and learning even during other class sessions ([18], [19]).

The usage of educational simulation in German universities and institutions of higher education in the field of construction industry is described in [20]. According to this research, the business games and educational simulations are mostly used for students in advanced phases of bachelor programs or master programs. The competency-orientation in curricula development could enhance the content-related quality of the educational simulation. The methodological competency, the awareness of relationships and the transfer of subject-specific competency were identified as being the most important ones in designing the educational simulation applied in German universities. As most relevant examples of educational business games and simulation products are considered: Bauwirtschaft, Unternehmensplanspiel Bau, BawiPLAN, Unternehmensplanspiel, Virtual Construction Company Competition, TOPSIM Project Management and Easy Start-Up. In [21] and [22], there are reported excellent results in implementing e-learning solution in construction management programmes.

3. Developing a Simulation Platform for Teaching Construction Project Financial Risks Management

3.1. The Architecture of the Simulation Platform

The objective of the educational simulation in construction project financial risks management is to contribute to the development of students' competencies in this subject. Graphical features of the tools used in the learning process allow the students to understand and to apply the recommended concepts, tools and methods. The visual mechanism of the educational simulation is developed from the contractor perspective and consists of several components for project financial risks management. The business logic for the educational simulation is the following:

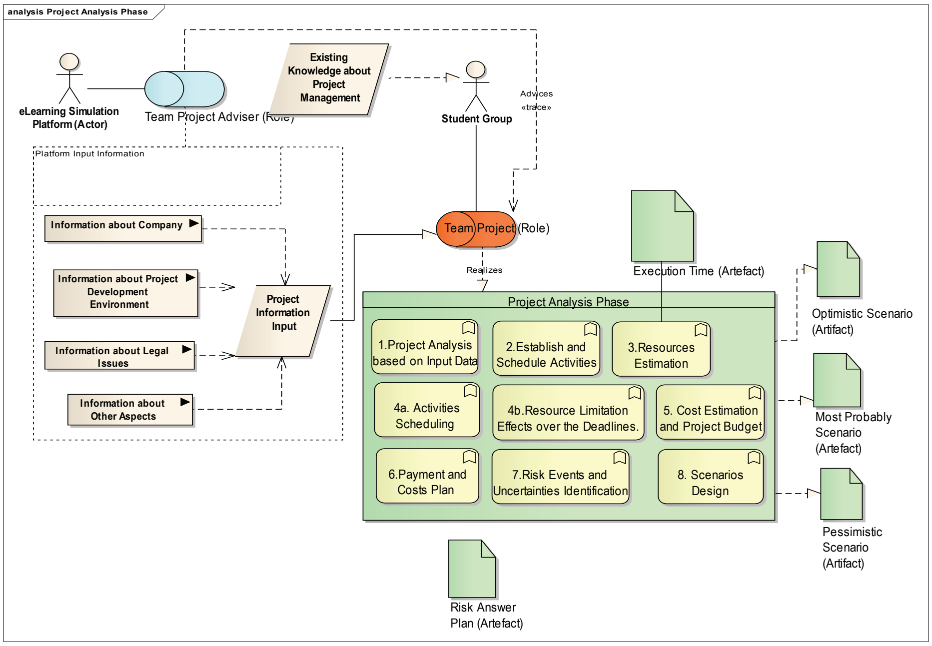
The project portfolio structure and the details projects are presented and discussed with the students. They get information regarding the projects description, the construction company capabilities, its position on the market, project stakeholders, assumptions and constraints, the type of contracts (based on measured quantities or lump sum), duration and the payment conditions.

Organized in teams, the students analyzes each project from all aspects related to scope, time, resources, cost, contract conditions of payments during the projects execution and those related to risk identification and prioritization and risk response plan. Based on the project's specific technology, the student's teams establish the activity level of detail and identify the construction processes to be performed. Once the activities sequence is defined, they estimates the needed resources according the volume of work and productivity, in order to fit the project duration within the contractual terms, and analyze the effect of limited resources on the execution terms. Based on historical information and databases, the students estimates the cost of resources and develop each project budgeting. According the contract clauses related to payment of works, they develop the schedule of payments and generate each project cash-flow. After that, the student's teams identify and prioritize the risk events, developing each project risk response plan. With this information, the student's teams define three project scenarios: optimistic, most probable and pessimistic, which will be used after that in risk quantification using Monte Carlo method.

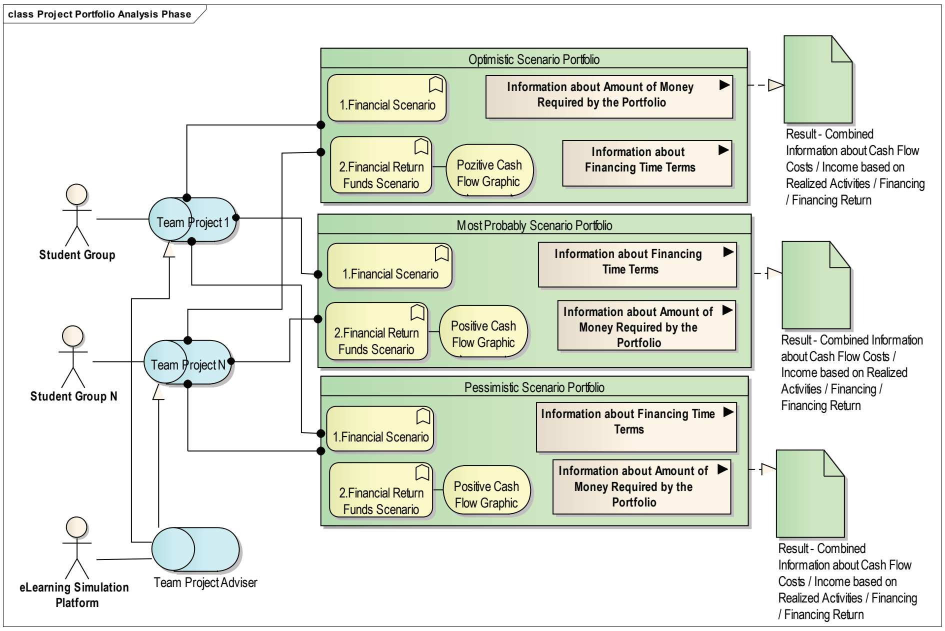
Having these results, all the student's teams participate in the aggregation of projects into the project portfolio on all three scenarios, identifying and analyzing the need of resources for projects completion and developing the portfolio cash-flow. Each student's team has now as aim the development of financing and return of financing scenarios in order to get a project portfolio cash-flow always positive, thereby providing complete support in performing all the projects within the project portfolio. This is intended to establish both the time and the amount of funding for covering the projects implementation in each time period and respectively the time and the amount of return of funding. The result is represented by the combined cash-flow of cost, incomes, financing and return of financing which must be always positive.

With the three project portfolio scenarios resulted from the aggregation of the optimistic, most probable and pessimistic projects scenarios and applying Monte Carlo method, the student's teams will establish the amount of financing with a reasonable probability to be achieved in order to ensure the implementation of all projects within the contractual terms. Such information is very useful in decision making, allowing the student's teams to establish the priorities for sustaining the projects both with physical resources and mostly with funding's.

The figures 1 and 2 present the detailed business and technique architecture, at project and portfolio levels.



(a) The first phase of the simulation (at the project level)



(b) The second phase of the simulation (at the project portfolio level)

Fig.1 The Detailed Business Architecture

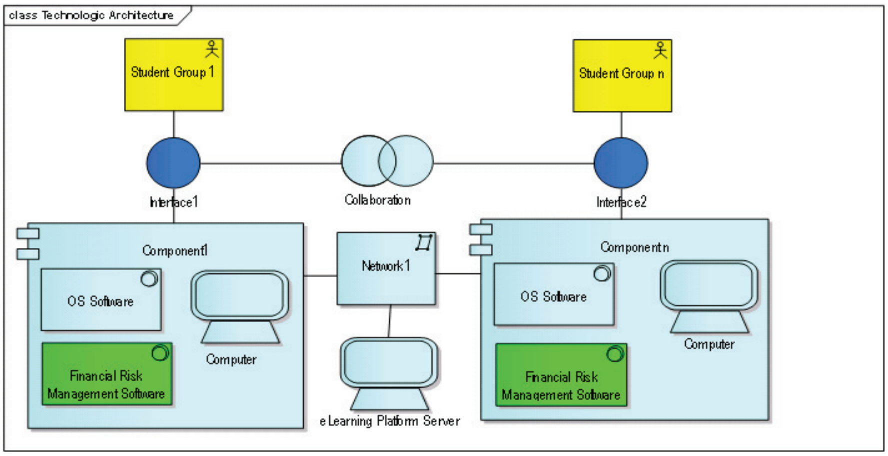


Fig.2 Technological architecture of the simulation platform

3.2. Simulation scenario: a Case Study

For any construction company the projects and projects portfolio financial aspects under the risk and uncertainties represents a real challenge. One major issue is to find an optimal or closed to optimal solution for ensuring financing and return of financing in such way the project portfolio cash-flow is always positive and to quantify the amount of financing for a reasonable probability under risk and uncertainties conditions. For this reason, the student's preparation in the master's degree program aims to achieve multiple skills aligned to project management best practices.

Such a case study is presented further. The project portfolio is consisted on several different type of construction works, including the construction of waste water plants, two rehabilitation of water supply and waste water network and one the rehabilitation of a road, on a total duration of 36 months.

The projects parameters – duration, contract price and estimated profit – are presented in the table 3:

Table 3. Projects parameters

Project	Duration	Contract Price (Euro)	Estimated Profit (Euro)
Project 1	21 months	12,415,171	620.758
Project 2	14 months	9,350,193	467.509
Project 3	24 months	4,461,781	204.608
Project 4	18 months	8,971,046	427.192
Portfolio	36 months	35,198,191	1.720.069

The project portfolio Gantt chart is shown in Fig. 3.

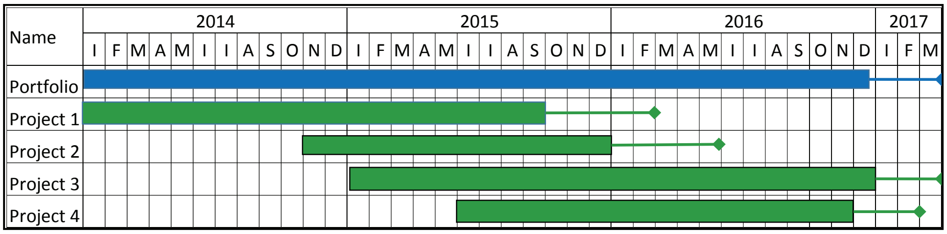


Fig.3 Project Portfolio Gantt chart

Each project is analyzed from scope, time, resources and cost point of view. The project's cash flows are developed taking into account the contractual clauses related to payment of works. In fig. 4 are shown the results of the cash flows for each project, consisted from the combination of costs with scheduled payments.

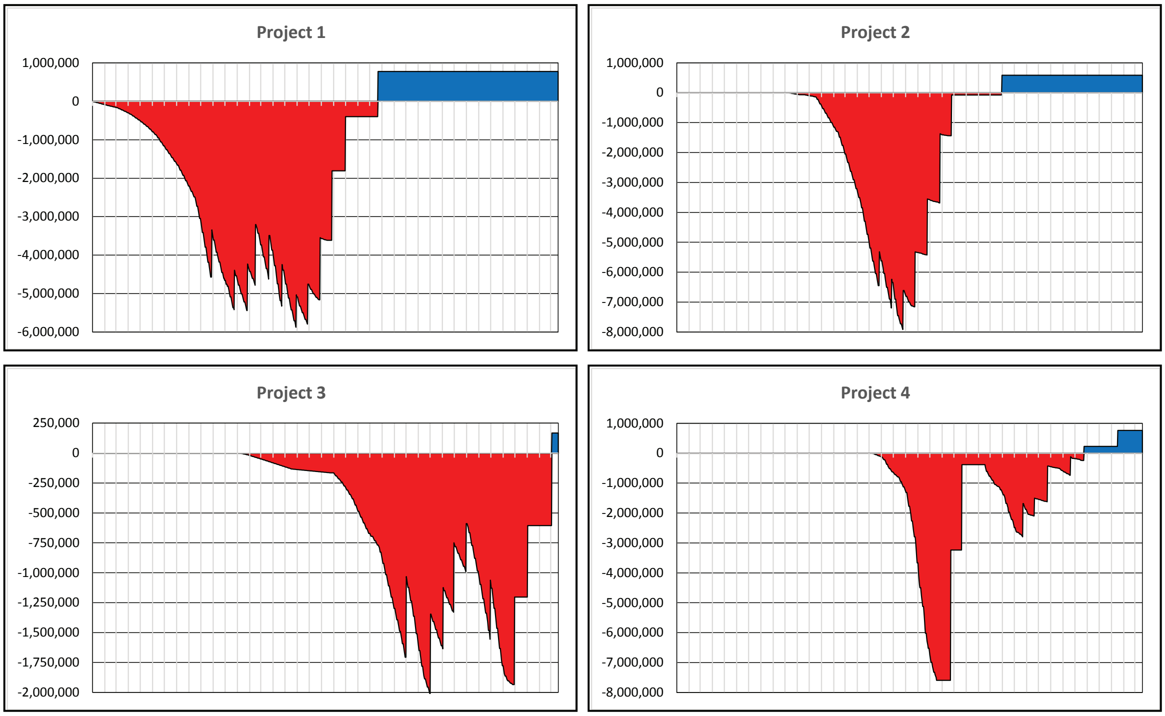


Fig.4 Projects Cash Flow

Analyzing the projects cash-flow, we can conclude that construction projects involve a tremendous financial effort. The peak of cash-flow varied from project to project based on the nature of works and the contractual clauses, as shown in the table 4.

Table 4. Projects peak of cash-flow

Project	Peak of Cash-Flow (Euro)	Weight
Project 1	5,876,473	47.33%
Project 2	7,918,731	84.69%
Project 3	2,021,374	45.30%
Project 4	7,594,419	84.65%

With peak of cash-flow varied from 45% to almost 85% from the contract price, the construction projects are a real challenge from financial point of view. However, aggregating the projects into the project portfolio may balance these weights due to the different time distribution of the component projects.

Aggregating the optimistic, most probable and pessimistic project's scenarios, we obtain three project portfolio scenarios which will be used in quantifying the amount of needed financing with a reasonable probability to be achieved in order to ensure the implementation of all the projects in contractual terms.

For the most probable project portfolio scenario the cash-flow is presented in fig. 5.

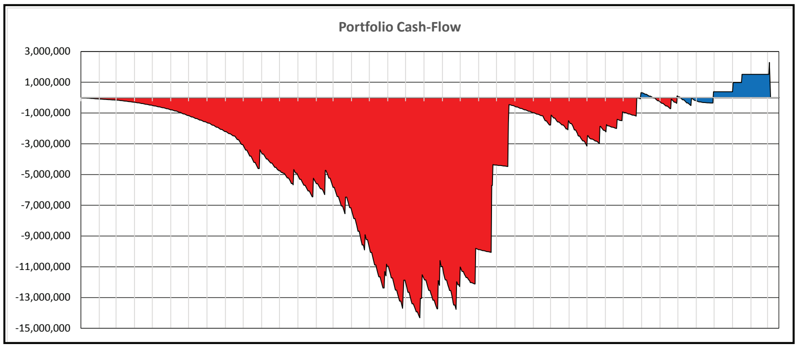


Fig.5 Project Portfolio Cash Flow

The project portfolio cash-flow is consisted from each project total cost (material, manpower, equipment, transport and overhead), the profit and the incomes resulted from the schedule of payments. For the most probable project portfolio scenario the peak of cash-flow is 14,317,383 Euro, representing 40.68% from all the contract price.

An always positive profile of the cash-flow at the project portfolio level which will ensure the implementation of all the projects involve an iterative process of establishing both a financing from internal or external sources and return of financing. For the time periods when the cash-flow has a descending trend, there will be established the time and the amount of funding able to cover the cost of works, while for the time periods when the cash-flow has an ascending trend, there will be established the time and the amount of the return of financing.

The results of this iterative process representing both the time and the amount of financing and return of financing are shown in fig. 6.

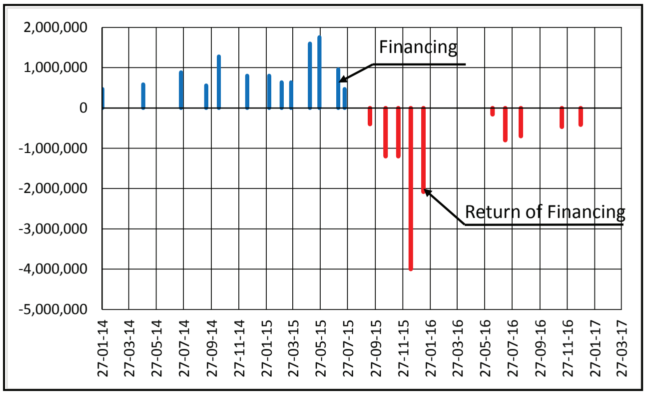


Fig.6 Portfolio Financing and Return of Financing

The cumulative curves of financing and return of financing together with the project portfolio cash-flow are shown in fig. 7. The financing cumulative curve covers in fact the project portfolio cash-flow when it has a descending trend, while the return of financing cumulative curve is overlapping with the time period when the cash-flow trend is ascending.

Consolidating the total cost of all the projects and the estimated profit with the incomes from schedule of payment together with the financing and return of financing resulted from the iterative process, we will obtain the combined cash-flow of the project portfolio. The results are presented as a graph (fig. 8) always positive, representing a feasible and reasonable scenario for projects implementation both technical and financial.

The optimistic, most probable and pessimistic project portfolio scenarios are used to quantify the amount of financing for a reasonable probability to be achieved.

For this purpose Monte Carlo method is applied with sufficient number of iterations in order to ensure the convergence of results.

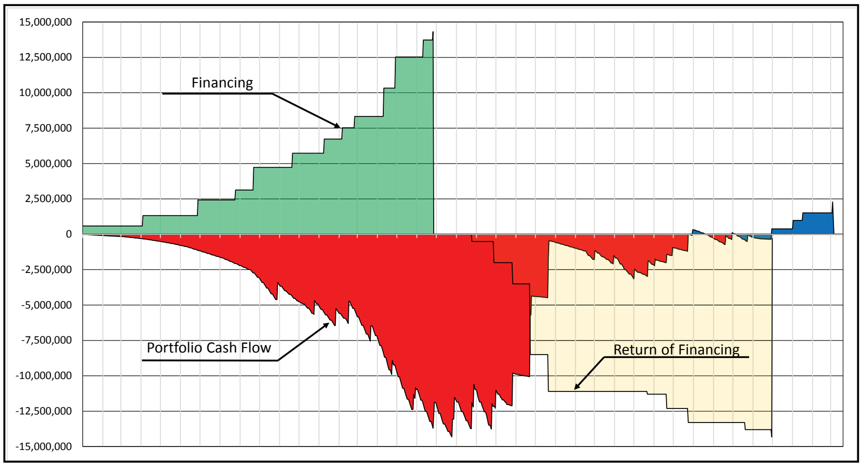


Fig.7 Portfolio Cash-Flow and Cummulative Financing and Return of Financing

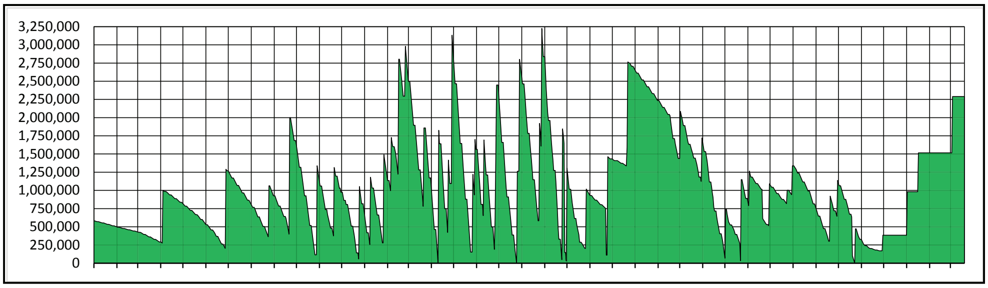


Fig.8 Portfolio combined Cash-Flow: financing, income from payments, costs and return of financing

The probability distribution and cumulative curve for our case study is shown in fig. 9.

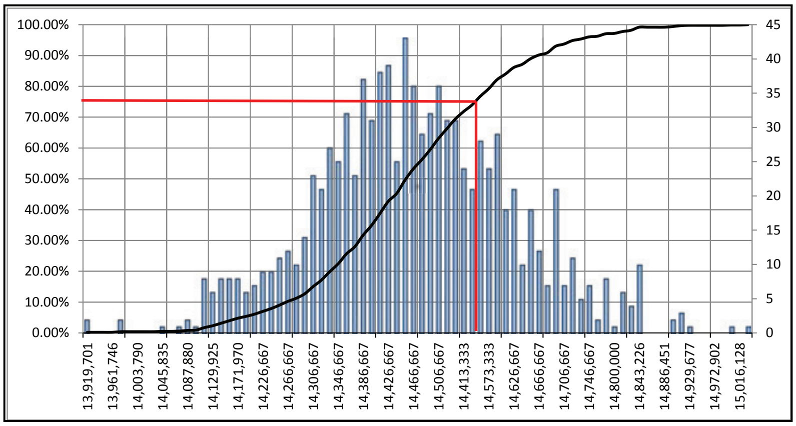


Fig.9 Cummulative probability curve for portfolio financing

Analyzing the results of risk quantification, for a reasonable probability of 75% which allows to cover the technical and financial risks and uncertainties, the total amount of financing is 14,500,000 Euro. Having sources for financing this amount of money will ensure the implementation of project portfolio within the contractual terms.

4. Conclusions and future work

Presenting high financial risks due to their complexity, the construction projects require competent project managers with skills and knowledge in project financial risks management. The classical approach in education, based on traditional methods for knowledge transfer has clear limits. The active and experiential way, stimulating the students to think creatively and to act properly as project managers brings value in their education. The experience gained in the master program of Project Management in Construction held in the Technical University of Civil Engineering, Bucharest, shows that educational simulations in construction project financial management contribute to the development of students' competencies in this area. Using graphical features of the tools in the learning process allow the students to understand and to apply the concepts, tools and methodologies used in project financial risks management. As future work, we consider to enrich the collaborative environment for simulations.

References

[1] A. Borghesi, B. Gaudenzi, Risk Management: How to Assess, Transfer and Communicate Critical Risks, Springer, Milan, 2013.
[2] N.N. Hlaing, D. Singh, R.L.K. Tiong, M. Ehrlich, Perceptions of Singapore construction contractors on construction risk identification, Journal of Financial Management of Property and Construction, vol. 13, no. 2, pp. 85-95, Emerald Group Publishing Ltd., 2008.
[3] A. Purnuş, C.N. Bodea, Project prioritization and portfolio performance measurement in project oriented organizations, Procedia - Social and Behavioral Sciences, 27th IPMA World Congress, 119(2014), pp. 339–348, Elsevier Ltd, DOI: 10.1016/J.SBSPRO.2014.03.039, ISSN: 1877-0428.
[4] KPMG International, Climbing the curve, Global Construction Survey 2015", KPMG International Cooperative available at: http://www.kpmg.com/global/en/issuesandinsights/articlespublications/global-construction-survey/pages/global-construction-survey-2015.aspx (accessed 10 May 2015).
[5] A. Purnuş, C.N. Bodea, Correlation between Time and Cost in a Quantitative Risk Analysis of Construction Projects, Procedia Engineering, Volume 85, Pages 436-445, Elsevier Ltd, 2014.
[6] S.H. Han, J.E. Diekmann, Y. Lee, J. H. Ock, Multicriteria Financial Portfolio Risk Management for International Projects, Journal of construction engineering and management, May/June, 2004.
[7] Project Management Institute, Construction extension to the PMBOK® Guide Third edition, Project Management Inc., 2007.
[8] S. Marttonen, Creating risk measurement model to project portfolio management in construction company, Lappeenranta University of Technology, School of Industrial Engineering and Management, Tampere, 2014.
[9] A. Purnuş, C.N. Bodea, A probabilistic approach of construction project financial management, Creative Construction Conference, Budapest, 2013, pp.649-660.
[10] T. Zayed, Y. Liu, Cash flow modeling for construction projects, Engineering Construction and Architectural Management, Vol. 21, No. 2, 2014, pp. 170-189, Emerald Group Publishing Ltd.
[11] Project Management Institute, The Standard for Project Portfolio, Third Edition, Project Management Inc., 2013.
[12] International Project Management Association, International competence baseline, V.4, 2015.
[13] J. Biggs, Teaching for Quality Learning at University – What the Student Does 2nd Edition SRHE / Open University Press, Buckingham, 2003.
[14] L.W. Anderson, D.R. Krathwohl, A Taxonomy for Learning, Teaching and Assessing: a Revision of Bloom's Taxonomy. New York. Longman Publishing, 2001.
[15] T. Orehn, Modeling and simulation: a comprehensive and integrative view, in: Yilmaz L., Oren T. (eds): Agent-based Simulation and Systems Engineering, Wiley-VCH, GmbH&Co, KgaA, Weinheim, 2009.
[16] J. Heineke, L. Meile, Classroom service game, Decision Science Institute Annual Meeting, November, 2000.
[17] K. Klassen, K.A. Wiloughby, In class simulation games: assessing student learning, Journal of Information Technology Education. Vol. 3. 2003.
[18] T. Korman, M. Kasensky, O. Drnek, K. Rahn, Using Simulations to better train future and existing Construction Management personnel, Proceedings of the Creative Construction Conference, 21-24 June, 2014, Prague.
[19] J. Zimmermann, W. Eber, Development of key performance indicators for organizational structures in construction and real estate management, Proceedings of the Creative Construction Conference, 21-24 June, 2014, Prague.
[20] C.K. Karl, Simulation and Gaming in Construction; Business, Design of a module-oriented modeling approach based on system dynamics and its prototypical implementation in research and education, PhD Dissertation, Department of Engineering Sciences, University of Duisburg-Essen, Germany, 2014.

[21] Bokor,O., Hajdu, M. (2014). *Teaching Construction Management Core Subjects with the Help of eLearning, Proceedings of the* Creative Construction Conference, 21-24 June, 2014, Prague, ISBN: 978-963-269-434-4.
[22] Bokor,O., Hajdu, M. (2014). *Writing E-Learning Materials for Construction Management Subjects*, Procedia - Social and Behavioral Sciences, 119, 758 – 765.