Academy-Industry Collaboration and the Effects of the Involvement of Undergraduate Students in Real World Activities

Elaine Venson, Rejane Figueiredo, Wander Silva, Luiz C. M. Ribeiro Júnior
ITRAC – Information Technology, Research and Application Center
Software Engineering Faculty
University of Brasília - UnB
Brasília, Brazil
{ ElaineVenson | RejaneCosta | WanderSilva | LCarlos }@unb.br

***Abstract*—As stated by the IEEE Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering, elements outside the classroom such as field trips, visits to industry and technical presentations can affect student's preparation for professional practice. This work describes a framework of academy-industry collaboration where students develop practical and academic activities in a real world scenario. It is a methodological research, in which a case study was conducted with a Government Agency that has a close collaboration with a University. This joint project led to the proposition of new software processes for the organization and produced research and capstone project papers. Results demonstrate that students have acquired experience in solving real world problems in the industry; they received recognition in the academic community through the acceptance of papers in international conferences; and also, the projects executed with the students produced outcomes that brought benefits to the government agency, under study.**

Keywords—software engineering education; capstone project case study, action research, IDEAL, industry.

I. INTRODUCTION

According to IEEE Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering [1], the involvement and active participation of industry is a critical element in the success for a software engineering program. In addition, relations between industry and academy can support a variety of activities such as student and faculty industrial internships, integration of industry projects into the curriculum, and industry guest lectures.

Some papers point to the dissatisfaction of software engineering professionals with their level of preparation for the real world when they start working in industry [2]. On the other hand, the software industry is also unsatisfied with the level of preparation of undergraduates that enter the software market [3].

Collaboration with industry is an important mean of research in the Software Engineering area. Although there are challenges involved in this type of partnership, industry-academy collaboration can lead to benefits for both parties. A recent study in Brazil suggests that Software Engineering academics should be more concerned in attracting research from industry [4].

According to Beckman, Coulter, Khajenoori and Mead [5], collaboration between Academy and Industry occurs when these two parties work together aiming a common goal. For this endeavor each one contributes with specific products and services. Wohlin [6] alerts that "it is actually not about doing studies 'in industry'; it is about doing studies 'with industry'". This is the mindset that should drive industry-university collaboration.

The benefits that can be accomplished from the collaboration between Industry and Academy worth the challenges imposed. In Brazil, these initiatives are still incipient [4]. Models and examples as shown in [5] and [6] can help Brazilian universities to start establishing partnerships and getting the benefits.

In this context, this work implement and evaluate a framework for academy-industry collaborations, based on an organizational improvement model (IDEAL [7]), where students develop practical and academic activities, aligned with student's capstone projects (students in his late semesters of the undergraduate course). According to the structure of the framework, students should develop academic activities and practices in a real scenario. Therefore, students have the opportunity to fill gaps in their education, by bringing academic knowledge to the industry and at the same time, scientifically evaluating the solution created and applied in a client organization. Furthermore, the results obtained with the capstone projects developed by the students can be published as scientific paper.

In order to analyze this framework, a case study was conducted with a Government Agency that has a close collaboration with a University. This joint project led to the proposition of new software processes for the organization and produced research and capstone project papers.

This work is organized in seven Sections. Section 2 has the theoretical reference on the industrial involvement in undergraduate Software Engineering course. Section 3 has the theoretical reference on the IDEAL model. Section 4 describes

the materials and methods used to produce this work. Section 5 presents the definition of the framework for students' involvement in real world activities by the mean of a capstone project. Section 6 presents the results. Finally, Section 7 provides the conclusions and suggestions for future work.

II. INDUSTRY INVOLVEMENT IN UNDERGRADUATE SOFTWARE ENGINEERING COURSE

According to [5], establishing collaboration between Industry and Academy can yield many benefits. The Industry can have access to new methods and technology at low cost. Other benefit is the possibility to influence academic programs. For the Academy, this close relationship with the Industry provides financial resources, access to real data to validate proposed models and opportunity to investigate real issues concerning the Software Engineering area [5].

However, there are some challenges to accomplish a successful partnership between Industry and Academia. Balancing long time research effort with urgent industry demands can be tricky. Industry has to understand that academic researchers are not consultants. Beckman, Coulter, Khajenoori and Mead [5] states that the key for a collaboration to be effective and practical is to "plan properly and communicate clearly so all interests are served".

Chen, Lu, An and Zhou [8] state that it is necessary to prepare students for the industry of software development, but this is a very complex task and that many universities are struggling to achieve.

Marques, Quispe and Ochoa [9] state that integrating practical experience in courses is a great and difficult challenge, sometimes impossible for most universities. They conduct a systematic mapping study on practical approaches to software engineering education [9], and part of the objectives is to answer the question: "*What are the main approaches used to address the practical experience in software engineering education*?".

As result, 173 papers were analyzed and the most cited approaches were learning by doing (more than half of studies), PBL / OBL, case studies, games learning, simulation, followed by some studies using traditional, open source, service learning and inverted classroom [9]. The authors [9] also points out that less than half of the studies report the use of the development process to guide the experiments. Of those reported, most used agile methods. According to the authors, it is likely that most cases were informal and guided by project deadlines, so were not reported.

The cooperation between Academia and Industry is addressed in the IEEE Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering [1]. According to it, the relationship between the industries and students can support a variety of activities, such as [1]:

- Case studies (exposure to real systems and project case studies);
- Project-based activities (group work, presentations, formal reviews, quality assurance);
- Capstone project (students in their last year should complete a significant project, developing team skills);
- Practical exercises (to develop skills in practices and processes); student work experience (internships, cooperative education, and sandwich work terms).

Regarding to the Capstone project activity, the guidelines [1] associate it with the Curriculum Guideline (CG) number 14, which define that the curriculum should have a significant real-world basis.

The IEEE Curriculum Guidelines [1] consider the capstone student project as an essential element of a software engineering degree program, as it provides the means for the students to deepen their knowledge of the course areas. According to it, the student capstone project is a significant experience at the *application level* of the Bloom taxonomy of learning [10]. The key characteristics of the project should consider the guidelines, as cited on TABLE I.

TABLE I. KEY CHARACTERISTICS OF THE CAPSTONE PROJECT ACCORDING TO IEEE [1]

Key characteristics of the project	Guidelines
Should span a full academic year	A full academic year is considered an adequate time for students to reflect upon experiences and retry solutions as appropriate.
Should preferably be undertaken as a group project	If such factors as assessment make this difficult, it is essential that there should be a separate group project of substantial size.
Should involve implementation	Implementation provide practical experience for the student, involving a wide set of software development activities.
Should have a "customer" other than the supervisor	With a real customer, the student gains fuller experience with product development life-cycle activities
Should be evaluated beyond concept implementation	The evaluation of project outcomes should go beyond concept implementation. Using walkthroughs, interviews, or simple experiments to assess the effectiveness and limitations of the deliverables.
Should be assessed by the practices and processes employed	Assessment of a capstone project should consider how effectively software engineering practices and processes have been employed, including the quality of student reflection on the experience, and not be based only on the delivery of a working system.

Bruegge, Krusche and Alperowitz [11] present a methodology that has two fundamental principles: ease of adapting to changing software requirements and early communication facilities. The methodology is based on the agile Scrum method (Rugby) and an approach of informal models to interaction between students and clients (Tornado). They concluded that the methodology has enough complexity to enrich the software engineering experience of students in a real environment and at the same time an educational environment that does not create undue barriers to students and instructors.

Kazi and Radulovic [12] present the balanced scorecard (BSC) framework adapted for software project management of students' teamwork. The model proposed include key performance indicators (KPI) that are used for evaluation of student individual and teamwork results, software metrics and

educational goals achievements. The authors defined a business process for students teams to monitor the software project, including strategic goals, perspectives measurements and performance measures related to the strategic goals. As an example, can be mentioned the strategic goal "Finalization of project according to specified scope of quality and time", which can be measured by the perspective (area) "Quality of project results" and in turn, have the performance measured by the "Number of bugs resolved ". This framework allows both students and instructors to monitor project progress and contributes to the evaluation process of student individual and teamwork.

III. PROCESS IMPROVEMENT PROGRAM - IDEAL

The IDEAL (Initiating, Diagnosing, Establishing, Acting, Learning) model is an organizational improvement model that serves as a roadmap for initiating, planning, and implementing improvement actions. The model was developed to be applicable not just to software process improvement, but to any improvement effort [7].

The IDEAL model proposes five phases for executing a process improvement cycle: the initiation effort, the diagnosis of the current status, the establishment of an approach and a plan to execute it; the action for the implementation of the plan; and lastly, the learning with the experience to propose future actions. By the end of each cycle involving the five steps, a capability status is accomplished. Fig. 2 presents the five IDEAL phases and respective activities [7].

Each phase of the IDEAL is performed through the execution of a set of activities. An initial process improvement infrastructure is put in place to *Manage the Process Improvement Program*. It is not considered a phase of the IDEAL model, but it underlies all five phases. The aim is manage the oversight to the improvement projects and resolve issues, as shown in TABLE II.

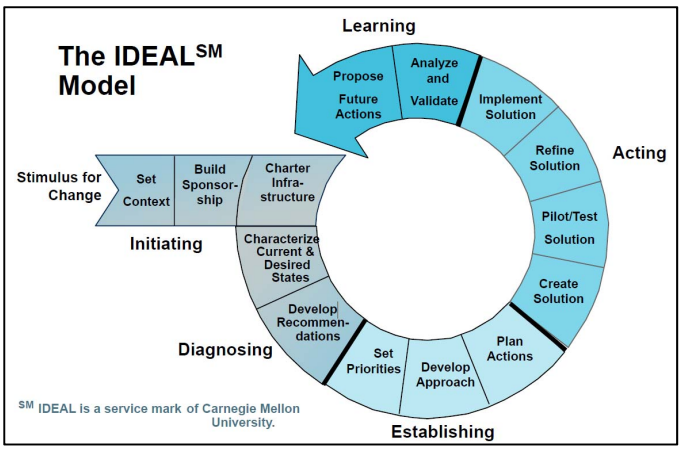

Fig. 1. Abordagem IDEAL [7]

IV. METHODOLOGY

This research is defined as methodological. According to Lima [13] methodological research involves an investigation of methods for collecting and organizing data and conducting researches. Furthermore, the methodological studies deal with the development, validation and evaluation of tools and research methods.

TABLE II. IDEAL PHASES AND ACTIVITIES [7]

Phases	Activities
Manage the Process Improvement Program	Provide oversight to the improvement projects and resolve issues
The Initiating phase	Identify the effort's contributions to business goals and objectives. Allocate initial resources, build a process infrastructure and insure work distribution.
The Diagnosing phase	Diagnose current levels of process. Communicate the organize a set of recommendations for improvement. Initiate action plan development.
The Establishing phase	Establish goals and priorities. Develop a detailed work plan, including the formation of work teams in the processes and the definition of strategies for improvement of the process
The Acting phase	Research and develop solutions to process problem. Do the work according to the plan
The Leveraging phase	Learn from the experience and improve your ability to prepare the next cycle through the IDEAL model, applying the lessons learned to refine the process

The present study was conducted in the area of Information Technology of the Ministry of Communications of Brazil. This government agency has a research and development agreement with the Gama Faculty of Engineering of the University of Brasilia (UnB), Brazil. This agreement lasted for three years and during this period it was possible to engage 7 students who developed their capstone projects.

All students involved in the project were undergraduate students of the Software Engineering course at UnB [14], enrolled between the fourth and tenth semester. In this course there is a call for the development of a capstone project divided in two parts. The first part is a qualifying work project, carried out through the ninth semester, and the second part is the final project completed at the end of the course.

This study was divided into five steps:

1) Elaboration: the relationship model to be followed was designed, based on the IDEAL model;

2) Alignment and Diagnosis: the students were included in the project, with the supervision of one or more professors of the Software Engineering course. In this moment it should occur the match between the practical issue (originated by the problems of the client organization) and the research interests of the student in respect of his capstone project. The practical problem was transformed in a research question, followed by the establishment of the goal and proposition of the research outline. The research was based on action-research and included procedures like bibliographic and documentary research, and interviews aiming at searching a solution for the initial issue from the client organization.

3) Proposition and Refinement: the student executed the proposed scientific methodology starting from the initial issue. As a result from this research cycle, he refined the solution and elaborated the lessons learned.

4) Solution testing and Capstone report writing: the student implemented the final solution on the client

organization and finished the writing of the report of his Capstone Project.

5) Presenting of the Capstone Project and papers writing: the student presented his project to an evaluation board composed by three professors (the advisor and two invited members). Beyond that, the student shall format his report to publish in scientific conferences or journals.

To evaluate the effectiveness of the framework, the following data were considered: 1) the work products delivered to the client, 2) the conclusion of the Capstone Projects, and 3) the papers published in scientific conferences and journals.

To certify the quality of these data, it was considered that the work products delivered to the client were subject to a validation process in which the client could approve or not the delivered solution. In relation to the Capstone Project, the quality criteria was accomplished with the approval and grade designated to the students by the professors who were part of the evaluation board. Finally, as the last stage, the quality was attested with the submission and acceptance of the papers to the scientific community.

V. Framework for Academy-Industry Collaboration

Based on the experience of a collaboration project between Brasília University (UnB) and the Ministry of Telecommunications (MC) in Brazil, a framework for students' involvement in real world research and application was conceived. The framework comprises the attempt to solve an issue for the IT Department of the client organization, in our case, Ministry of Telecommunications. Each issue becomes a subject for a student to develop his capstone project for the Software Engineering course of the UnB.

A professor who is member of the collaboration project and who coaches the student in his capstone project, assign a small team, usually two to four other students, who will support the lead student. Typically, the lead student is in the last year of the course, whereas the supporting students are in the third or fourth year. The professor guides the students during the whole experience through weekly internal meetings and meetings in the client organization. Professor, lead student and support students together compose the academic team.

In the client organization, the projects are sponsored by the IT area coordinator and monitored by the project office. Coordinators of subareas of IT and participants of the business areas of the organization are also involved, depending on the matter in question.

The framework is based on the IDEAL model [11]. The first three stages of IDEAL, namely Initiating, Diagnosing and Establishing, compose a first phase of each project and the other two stages, Acting and Learning, constitute the second phase. Therefore, to fulfill one entire issue it is necessary to execute the two phases provided by the framework. Each phase is executed through a two-semester capstone project. Thus, in phase 2, the lead student continues the work produced by other student in phase 1.

The main goal of the first phase is to propose a solution for the issue of the client organization. Fig. 2 presents the Phase 1 process. It initiates with the diagnosis of the situation, which can include data collection techniques such as interviews, questionnaires and observation.

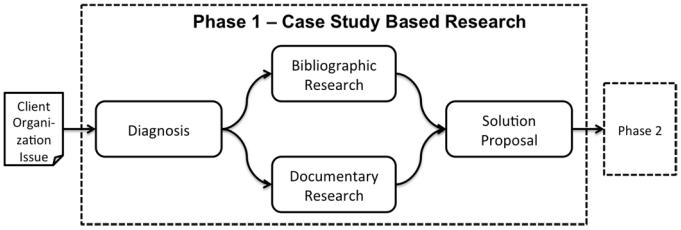

Fig. 2. Phase 1 for solution design

The next two steps occur in parallel and comprise the theoretical background that shall be acquired by the students to propose the solution. Bibliographic research provides the academic knowledge, whereas documentary research allows recognizing any regulatory norms or other documents related to the subject. The outcome of this process is a possible solution for the initial issue of the client organization. The whole process of Phase 1 is methodologically conducted as a case study in the client organization.

The second phase aims at validating the proposed solution (see Fig. 3). It begins with successive refinements of the proposal, which are executed through action research cycles.

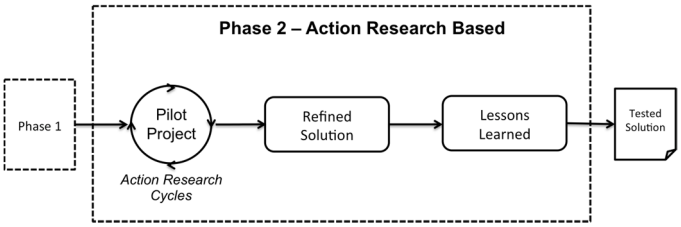

Fig. 3. Phase 2 for solution evaluation

The first cycles comprise revision meetings with the stakeholders, where adjustments can be applied to the original solution. The following cycles aim at testing the solution by the means of pilot projects, which are executed in the client organization. The academic team monitors the pilot projects and conducts cycles evaluation, in which they present measurements, collected during the cycle and discuss the results with the stakeholders. As the pilot project finishes, the solution is refined and tested, being validated for a broader application in the organization. At the end, lessons learned are discussed and registered for future projects utilization.

TABLE III. presents roles and activities performed in Phase 1 and Phase 2 accordingly to the stages of the IDEAL model.

All capstone projects follow guidelines provided by the Brasília University and the Software Engineering Course. The student responsible by the project is evaluated in both first and second semesters of the Capstone project. The student hands a research report and present his work to an evaluation board composed by the professor advisor and two other professors from the institution or from external organizations.

TABLE III. ROLES AND ACTIVITIES OF THE FRAMEWORK ALIGNED TO THE PHASES OF THE IDEAL MODEL

IDEAL Phases	**Activities by Role**		
	Ministry	***Advisors***	***Students***
Manage the Process Improvement Program	Establish goals and objectives for the collaboration program. Determine organizational structure for managing and coordinating the collaboration program	Ensure consistency with business objectives and critical business needs previously identified. Establish goals and objectives for the collaboration program from a management perspective of researches. Determine organizational structure for managing and coordinating the collaboration program, including roles and responsibilities of advisors and students (novices, seniors). Determine scope of collaboration program.	All students support activities of the project.
The Initiating Phase	*For each stimulus for change defined by the Ministry:* The purpose is to set, from a management perspective, the key business needs driving the requirement for an activity. Allocate initial resources. Build a process infrastructure and insure work distribution in Ministry.	**Identify the effort's contributions to business goals and objectives.** Review current vision statements and process business focus. • Collect any current needs identification documents; • Interview key management stakeholders; • Review needs to determine those that can be fully or partially satisfied through a collaboration program; • Define how the collaboration program can satisfy the business needs. Determine scope of activity. **Allocate initial resources** to begin work (people's time will be allocated - novice and senior students) **Build a process infrastructure and insure work distribution.** • Introduce and involve key stakeholders in Communicating; Establish Infrastructure; • Maintain visibility for the program; • Facilitate and encourage information sharing. • Capture and retain lessons learned and improvements developed.	**Identify the effort's contributions to business goals and objectives.** • Analyze the demands and opportunities; • Support the revision of the current vision statements and business process; • Support interviews with stakeholders and data collecting; • Study Ministry's information. **Build a process infrastructure and insure work distribution.** • Support information sharing between Ministry and researchers. ** ***Lead Student*** • Defines the subject of his work and initiate bibliographic and documentary research.
	Together, Ministry and advisors, prioritize the issues to be addressed.		
The Diagnosing Phase	Insure that all aspects of the organization will be provided to researches. Insure the availability of stakeholders to provide information. Insure the necessary infrastructure supply.	To accomplish the activities, it is required a coordination of people, data, facilities, training activities and support services. **Diagnose current levels of process.** • Characterize current and desired states (It can be done using a reference standard such as Agile methods); • Analysis of the solutions adopted in other Ministries; Selection of bibliographic and documentary sources to be provided to the students. **Communicate the organization a set of recommendations for improvement.** •The recommendations developed suggest a way of proceeding in subsequent activities.	**Diagnose current levels of process.** • Perform new bibliographic and documentary researches; • Elaborate summaries and short presentations of the selected sources for group disussion (advisors and students); • Participate in refinement discussions in group (advisors and students; student and students); • "Senior students" support the integration of "novice students"; ** ***Lead Student*** • Initiate the characterization of the case study; • Write the Capstone Project report, with the theoretical background and case study characterization.
		Perform meetings and interviews with the Ministry. Perform internal meetings (advisors and students) to define the solution. **Initiate action plan development (Strategic Plan).**	
The Establishing Phase	Receives and evaluate the Strategic Plan. Evaluates and approves goals and priorities. Approves the detailed work plan. And Support the definition of strategies for improvement of the process.	Create - Update the Strategic Plan Establish goals and priorities. Develop a detailed work plan: • Including the formation of work teams in the processes and • The definition of strategies for improvement of the process Define a new *Students Working Group* to next *Acting Phase*	Students support: • Creation – Update the Strategic Plan; • Establishing goals and priorities; • Developing a detailed work plan; • The definition of strategies for improvement of the process. ** ***Lead Student*** • Develops a proposal of solution for the initial issue; • Present the project to a board of professors.
	Build Consensus, Review, and Approve the Strategic Plan and Commit.		
The Acting Phase	Analyzes the proposed solution. Approves the execution of a pilot-project. Determine Long-Term Support Needs	Complete Tactical Plan for Working Group • Assign a new ***Student Capstone Project***; • Selects bibliographic and documentary sources for the students group to study; • Research and develop solutions to process problem; • Develop Solutions.	• Support to development Tactical Plan for Working Group; • Analyze the demands and opportunities; • Research and develop solutions to process problem; •Develop Solutions. ** ***Lead Student*** • Write the Capstone Project report, with the theoretical background and case study characterization; • Develops a proposal of a solution definition for the issue (provides for action research cycles); • Presents the project to a board of professors.
	Together, Ministry and advisors define Pilot Potential Solutions. Define action research cycles.		
	Select Solution Providers Package the Improvement and Turn Over to the Software Engineering Process Group	Develop Rollout Strategy Plan Template Rollout Solution	Follow the cycles of action research, collect and record data ** ***Lead Student*** • Refines the solution and write the Capstone Project report; • Presents the project to a board of professors.
	Perform meetings and interviews with the Ministry. For each executed cycle measurements data are collected and the solution is refined.		
The Leveraging Phase	Learn from the experience and improve abilities to prepare the next cycle through the IDEAL model, applying the lessons learned to refine the process.		

VI. Results and Discussion

The collaboration framework is being executed for three years. In this period, 7 students executed Phase 1 and Phase 2 projects applying the framework.

The Capstone Projects executed are shown in TABLE IV. The students were approved by a board of professors, achieving high grades. Only one student got a 'B' (*his literature review was weak*), all others received an 'A' grade.

The outcomes for the organization and academic results are shown in TABLE V. The organization issues were related to the need of improvement in development, maintenance and inventory processes.

As outcomes for the client organization, three new processes were deployed, which involved the entire IT area and business stakeholders of the Ministry. The Management Process for Outsourcing Software Development Demands based on Scrum was applied in the organization's recent contract and it is in execution. The Management Process of Outsourcing Maintenance Demands based on Kanban is currently being deployed. The Processes for Systems Inventory are already in use.

TABLE IV. Capstone Projects Executed and Assessment

Student	Semester 1 (Qualification)		Semester 2 (Complete Project)	
	Work Title	Grade	Work Title	Grade
1	Knowledge Transfer in Software Factories Contracting Processes	A	Knowledge Transfer in Software Factories Contracting by Public Organizations	A
2	(Executed in another context)	-	Applying Scrum in a Management Process for Outsourced Software Development Demands in a Brazilian Public Organization	A
3	Knowledge Transfer in Software Factories Contracting: an Action-Research in a Brazilian Public Body	A	Applying Scrum in Software Factory Contracting: an action-research in a Brazilian Public Organization	A
4	Applying Kanban in a management process of outsourced software maintenance demands for a Brazilian Public Organization	B	Applying Kanban in a management process of outsourced software maintenance demands for a Brazilian Public Organization	A
5	Applying Kanban in the treatment of software maintenance demands: an action-research in a Brazilian Public Organization	A	Applying Kanban in the treatment of software maintenance demands: an action-research in a Brazilian Public Organization	A
6	Proposal of a Legacy Software Inventory Process in a Brazilian Public Organization	A	Software Inventory Process in a Brazilian Public Organization	A
7	Deploying Software Inventory Processes in a Brazilian Public Organization: an action-research	A	(currently in execution)	-

TABLE V. Capstone Projects Executed and Outcomes

Student	Organization Issue	Framework Phase	Outcomes for the Client Organization	Published/To publish Papers	Conference	Date
1	Improve software development outsourcing process – Knowledge Transfer	Phase 1	Proposal of Knowledge Transfer Elements for Software Factories Contracting Process. Training	Knowledge Transfer in Outsourcing Software Development Projects	CONTECSI [15]	2015
				Knowledge Transfer in a Management Process for Agile Software Development Demands	HICSS	Submitted in June 2016
2	Improve software development outsourcing process	Phase 1	Proposal of a Management Process for Outsourcing Software Development Demands based on Scrum (GEDDAS)	Application of the Scrum Agile Framework to the Management Process of Software Development Outsourcing In A Brazilian Government Agency	CONTECSI [16]	2015
3	Improve software development outsourcing process	Phase 2	Evaluation of a Management Process for Outsourcing Software Development Demands based on Scrum (GEDDAS)"	"Experiência no Projeto Framework de Soluções de TI"	FEES [17]	2014
				Using Scrum in Outsourced Government Projects: An Action Research	HICSS [18]	2016
4	Software maintenance outsourcing process Improve	Phase 1	Proposal of the Application of Kanban to the Management Process of Outsourcing Maintenance Demands (GEDEM)	Using Kanban in Outsourced Government Projects of Management Maintenance Demands: a Descriptive Research	CONTECSI [19]	2016
5	Improve software maintenance outsourcing process	Phase 2	Evaluation of the Application of Kanban to the Management Process of Outsourcing Maintenance (GEDEM)	Using Kanban in Outsourced Software Maintenance Demands of a Public Organization: An Action Research	-	To be submitted
6	Improve change management process	Phase 1	Proposal of a Systems Inventory Process	Systems Inventory in a Brazilian Public Body	ICSME	Submitted in July 2016
7	Improve change management process	Phase 2	Evaluation of a Systems Inventory Process	Systems Inventory in a Brazilian Public Organization: an Action Research	-	To be submitted

As academic results, five papers were published in two international conferences and one paper in a Brazilian conference. Other three are in the process of revision or submitting.

From the IEEE Curriculum Guidelines perspective, the framework is enabling our Capstone Projects to follow the key characteristic suggested (shown in TABLE I).

The key characteristics are present in the framework in the following ways:

- Should span a full academic year: each phase of the framework comprise a two-semester project;
- Should preferably be undertaken as a group project: the projects are leaded by one student and supported by other novice students, besides the professor that coaches it;
- Should involve implementation: the project provides the practical experience for the students as it involves the design and the evaluation of a solution that will potentially solve problems for the IT Department of an organization;
- Should have a "customer" other than the supervisor: during the project, the student has to face and deal with real clients, with real problems and demands;
- Should be evaluated beyond concept implementation: the students are required to apply research techniques to collect data and evaluate the effectiveness and limitations of the solutions proposed;
- Should be assessed by the practices and processes employed: the capstone project is evaluated through a board of professors or other external stakeholders, which can include stakeholders of the client organization.

VII. CONCLUSION

It was presented a framework based on the existence of an industry-academy collaboration project. Collaboration can be considered a joint effort wherein each party provides specific products and services toward a common goal. According to the framework, industry provides the corporate issues that can be investigated through applied research, while the academy provides the students as the research workforce along with the professors as advisors.

Results demonstrate that by applying the framework, students have acquired experience in solving real world problems through the execution of Capstone projects in the industry. In addition to the professional experience acquired, students have received recognition in the academic community through the publishing of papers in international conferences. Also, the projects executed with the students produced outcomes that brought benefits to the government agency, under study.

As a future work we intend to evaluate the framework from the perceptions of the individuals involved in the process, including professors, students and client organization. We also envision another analysis of the framework from the perspective of the Bloom taxonomy regarding the students development in the Software Engineering course.

REFERENCES

[1] ACM/IEEE Joint Task Force on Computing Curricula, "Software Engineering 2014-SE2014 Curriculum guidelines for undergraduate degree programs in computer engineering", a volume of the Computing Curricula Series, copyright ACM and IEEE, published by the IEEE Computer Society, February 2015. Disponível em: http://www.acm.org/education/se2014.pdf

[2] Exter, M., Comparing Educational Experiences and On-the-job Needs of Educational Software Designers. In: Proceedings of the 45th ACM Technical Symposium on Computer Science Education, SIGCSE '14. New York, NY, USA: ACM, (2014): 355–360.

[3] Portela, C. S.; Vasconcelos, A. M. L. How to Develop Competencies and Abilities Professional in Software Engineering in Undergraduate Students?. In: International Conference on Frontiers in Education: Computer Science and Computer Engineering, 2015, Las Vegas. Proceedings of the XI International Conference on Frontiers in Education: Computer Science and Computer Engineering (FECS 2015): 91-94.

[4] J. Sousa Gomes, P. A. da Mota Silveira Neto, D. S. Cruzes, and E. Santana de Almeida, "25 Years of Software Engineering in Brazil: An Analysis of SBES History," in *2011 25th Brazilian Symposium on Software Engineering (SBES)*, 2011, pp. 4–13.

[5] H. Beckman, N. Coulter, S. Khajenoori, and N. R. Mead, "Collaborations: closing the industry-academia gap," *IEEE Software*, vol. 14, no. 6, pp. 49–57, Nov. 1997.

[6] C. Wohlin, "Empirical software engineering research with industry: Top 10 challenges," in *2013 1st International Workshop on Conducting Empirical Studies in Industry (CESI)*, 2013, pp. 43–46.

[7] J. Gremba, C. Myers. The IDEAL Model: A practical guide for improvement. Software Engineering Institute (SEI), 1997. [Online]. Available: http://www.sei.cmu.edu/library/assets/idealmodel.pdf. [Accessed: 16-Apr-2016].

[8] Chen, J., H. Lu, L. An, and Y. Zhou. "Exploring Teaching Methods in Software Engineering Education". Proceedings of the 4th International Conference on Computer Science & Education (ICSE). IEEE Press (2009): 1733-1738.

[9] M. R. Marques; A. Quispe; S. F. Ochoa. A systematic mapping study on practical approaches to teaching software engineering. In: Frontiers in Education Conference (FIE), (2014): 1-8, IEEE

[10] B.S. Bloom. Taxonomy of Educational Objectives: The Classification of Educational Goals: Handbook I, Cognitive Domain, Longmans, 1956.

[11] B. Bruegge, S. Krusche, l. Alperowitz. Software engineering project courses with industrial clients. ACM Trans. Comput. Educ. Vol. 15, No. 4, (December 2015).

[12] Lj. Kazi, B. Radulovic. Information system based on balanced scorecard for student teamwork software project management. In: Mipro, 2011 Proceedings of the 34th International Convention, Opatija, Croatia, 23-27 May, 2011.

[13] Lima D. V. M. Research design: a contribution to the author. Online Brazilian Journal of Nursing. Vol. 10, no. 2, abr-ago. 2011.

[14] R. M. C. Figueiredo, A. B. C. Sales, L. C. M . Ribeiro Jr, L. A. F. Laranjeira, A. F. Rocha. Teaching Software Quality in an Interdisciplinary Course of Engineering In: 7th International Conference on the Quality of Information and Communications Technology – QUATIC. 29 Set - 02 Oct., 2010, Porto, Portugal. Los Alamitos, California, USA: IEEE Computer Society Press, 2010.

[15] M. F. Brito, R. M. C. Figueiredo, E. Venson, Ribeiro Jr., L. C. M., R. A. Kosloski. Knowledge transfer in outsourcing software development projects. In: 12th CONTECSI - International Conference on Information Systems and Technology Management, Sao Paulo,SP – Brazil (maio 2015).

[16] L. P. Souza Sobrinho, R. M. C. Figueiredo, E. Venson, L. C. M. Ribeiro Jr., R. A. Kosloski. Application of Scrum Agille Framework to the Management process of development outsourcing in a Brazilian Government Agency. In: 12th CONTECSI - International Conference on Information Systems and Technology Management, Sao Paulo,SP – Brazil (maio 2015).

[17] T. Sousa, R. M. C. Figueiredo, E. Venson, R. A. Kosloski. Experiência no Projeto Framework de Soluções de TI. In: VII Fórum de Educação em Engenharia de Software (FEES 2014), Evento integrante do XXVIII Simpósio Brasileiro de Engenharia de Software (SBES 2014), 2014, Maceió. AL. Brazil.

[18] T. Sousa, E. Venson, R. M. C. Figueiredo, R. A. Kosloski, Rbeiro Jr., L. C. M., Using Scrum in Outsourced Government Projects: An Action Research, In: 2016 49th Hawaii International Conference on System Sciences (HICSS), IEEE, 2016, pp.5447, Koloa, Hawaii.

[19] J. V. P. Santos, Noronha, A. P., R. M. C. Figueiredo, E. Venson. Using Kanban in Outsourced Government Projects of Management Maintenance Demands: a Descriptive Research. In: 13th International Conference on Information Systems and Technology Management, 2016, São Paulo, SP., Brazil.