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Abstract. *This technical report describes the Freshmen Programming Competition at the Information Systems Undergraduate Program of the University of São Paulo – a programming championship for freshmen, organized by professors and sophomore and junior students. The sophomore and junior students belong to the board of scholarship students of the federal Tutorial Education Program, deployed in the context of the Information System Undergraduate Program.*

1. Introduction

The Freshmen Programming Competition at the Information Systems Undergraduate Program is an activity designed to help stimulate the learning of programming among students. Known as BXCOMP, an acronym for the expression in Portuguese *Campeonato para Calouros* or *Campeonato para Bixos*[1] (Freshmen's Championship or *Bixos*' Championship), this competition has been organized by students since its first edition, back in 2011, on an yearly basis. To present its history and context, we have written this technical report, hoping that our experience may inspire others to bring such initiatives to students in their own institutions.

In this report we describe the context in which BXCOMP has been historically carried out, as well as some of the procedures involved in its planning and execution. The rest of this document is organized as follows: in the first two sections, general information about the context of the Information Systems Undergraduate Program and the Tutorial Education Program are presented; in Section 4, details regarding the set-up and execution of the championship are presented; the report is ended with some considerations about benefits the championship has brought to the students and some of the future directions for this activity.

2. The Information Systems Undergraduate Program

The Information Systems Undergraduate Program (ISup) is a course offered at the School of Arts, Sciences and Humanities (EACH) of the University of São Paulo (USP) since 2005. Ten other undergraduate courses are also offered at the same School, along with eleven graduate programs, in different knowledge areas (including pedagogy, health, and social sciences). The ISup is organized in two periods: one class in the morning and two in the evening, with a total of 180 students enrolling every year.

[1]*Bixos*: slang traditionally used by students to designate the student entering a course.

The school has a management and pedagogical system that promotes a strong interaction among lecturers, practitioners and students from different knowledge fields, creating a rich environment for the development of interdisciplinary projects. The formal pedagogical guidelines at EACH-USP include the use of active methodologies, such as Problem-based Learning (PBL), for example, in the context of several courses offered in all undergraduate programs. As a methodology, PBL emphasizes two main goals in the teaching-learning process: (i) the student's positioning in a leading role in the process [Mergendoller et al. 2006]; and (ii) the inclusion of teaching practice in a learning environment where theory and practice can be easily brought together [Savery 2009].

Mainly because ISup is included in an interdisciplinary structure, it has a unique curricular program in Brazil. Part of it, called the basic cycle, is also shared with other undergraduate programs at the School. Its syllabus represents 15.8% of the whole of ISup's curricular program, being related to a number of transversal themes, such as scientific methodology, data analysis, science of nature, law, psychology, education and arts, with the ultimate goal of building the conditions for students to gather experience in subjects transcending the technical knowledge. The remaining 84.2% of ISup's curricular program comprise its technical part, which is related to computer technology and its fundamentals, information systems and mathematics, within social and professional contexts.

Aiming at providing extensive training to students, thereby making them understand computer science as an "means-activity", ISup's official Pedagogical Project recommends a strong emphasis on practical classes (laboratories) and examples (cases), in order to have undergraduates efficiently use technology in their future work places. Accordingly, it is notorious the existing relationship between the technical education of a professional in the field of information systems, his/her knowledge about computer related contents, and the need to develop skills and competencies related to logical reasoning and creativity in solving problems – features that can be enhanced by activities such as the experience discussed in this report.

In order to promote the full development of students' logical reasoning, along with their programming and problem-solving abilities, ISup's Educational Project includes seven programming related courses (two of which are optional to the student). These are:

- Introduction to Programming (IP): introduces the student to the basic concepts of computer programming, under the object oriented paradigm. It is offered in the first period of ISup, with a 120 hour workload.
- Introduction to the Analysis of Algorithms (IAA): presents the students with techniques for the development of well-structured computer programs, also introducing them to the asymptotic analysis of algorithms. It is offered in the second period of ISup, with a 120 hour workload.
- Algorithms and Data Structures I (ADS I): introduces the students to some data structures in main memory. It is offered in the second period[2] of ISup, with a 120 hour workload.
- Algorithms and Data Structures II (ADS II): it is a sequence to ADS I, introducing the students to data structures in secondary memory, along with more advanced

[2]Offered in the third period of the course until 2012, it was moved to the second period after that.

structures in main memory, such as graphs for examples. It is offered in the third period of ISup, with a 120 hour workload.

- Object-Oriented Computing (OOC): introduces the students to advanced concepts of object oriented programming, along with software design concepts under this paradigm. It is offered in the third period of ISup, with a 60 hour workload.
- Programming Challenges I (PC I - optional): aims at developing computational problem solving skills in a collaborative environment under pressure. The environment is similar to that of international programming contests such as ACM-ICPC. The proposed problems induce the students to learn techniques for the development and analysis of algorithms, also giving them some teamwork experience. It is offered in the seventh period of ISup with a total workload of 60 hours.
- Programming Challenges II (PC II - optional): an extension to PC I, with more complex problems being presented to students. It is offered in the eighth period of ISup with a total workload of 60 hours.

Apart from the courses related to computer programming, ISup's curricular program also includes compulsory courses that are part of its Mathematical core, such as Calculus I and II (CALC I and CALC II), Discrete Mathematics I (DM I), Matrices, Vectors and Analytical Geometry (MVAG). Figure 1 shows a snippet of the curricular program regarding the aforementioned courses. The program is shown as a prerequisite graph because these are courses that are directly or indirectly linked to the activities discussed in this report.

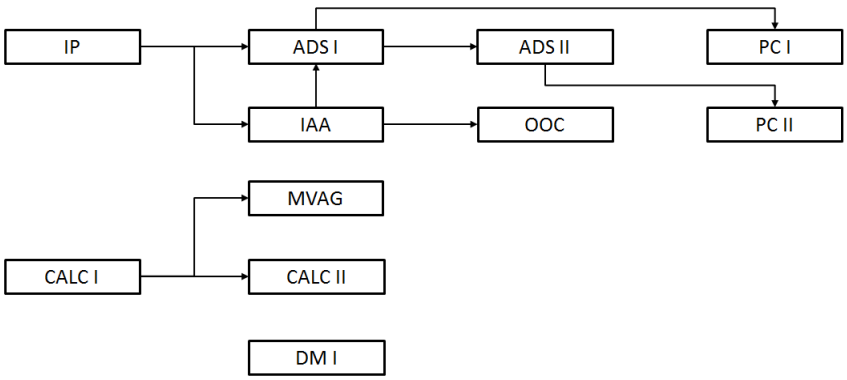


Figure 1. Prerequisite graph regarding part of ISup's curricular program

3. The PET Program and the PET-SI group

The Tutorial Education Program (PET in its acronym in Portuguese) is an initiative of the Brazilian Government started in 1999 as a redesign of a similar program (that had been active since 1979). Its main goal is to improve Brazilian undergraduate programs, by promoting an extensive training of undergraduate students both directly and indirectly involved with it. As a secondary goal, PET seeks to encourage the establishment of values that reinforce citizenship and social conscience in this group of students. In order to achieve these objectives, PET is composed of tutorial education groups, formed by undergraduate students and a professor, who works as a tutor, guiding the students in some specific extracurricular activities. These activities must be related to teaching, research

and extension, to complement the students' academic training. The University of São Paulo was one of the first institutions in Brazil allowed to start a PET group, currently hosting 23 groups in different knowledge areas.

The Information Systems PET group (PET-SI) was established in December 2010, in association to ISup (EACH-USP). Since its establishment, 68 undergraduate students, usually sophomores and juniors, took part in the group, carrying out different extracurricular activities, such as junior scientific projects, organization of national and local technical-scientific conferences, development and maintenance of academic websites, technical visits in computer-related companies, development of academic newspaper editions, organization of coding dojos for students from technical high schools, development of projects to promote gender equality in the field of Information Systems and the organization of the programming competition for ISup's freshmen – BXCOMP.

4. The Programming Competition for Freshmen - BXCOMP

The Programming Competition for ISup's Freshmen, BXCOMP, is a competition comprising seven rounds, which are run over seven weeks, and where participating teams accumulate points according to their performance during each round. This activity was originally devised by the PET-SI group in 2011. Ever since, the competition has been organized by this group, with help from ISup's program coordinator and teachers of programming logic and data structures courses. BXCOMP takes as its target audience ISup's freshmen, seeking to offer them an extracurricular activity to promote an entertaining environment for cooperative and collaborative work. Moreover, this activity can contribute to the development of other skills and competencies, such as planning, problem-solving and conflict management abilities, along with their capacity to act under pressure.

BXCOMP also provides an opportunity for the development of special skills and expertises in students. During the activity, PET-SI students are presented with situations that require the planning and organization of competitions, the practicing related to the teaching-learning process, and the acquaintanceship with concepts such as ethics and morality. All these aspects enhance the sense of responsibility and critical thinking of students. Additional information about each championship edition can be found in their respective homepages[3]: `www.each.usp.br/petsi/bxcomp201X`, with X ranging from 1 to 7.

4.1. BXCOMP History

Up to its seventh edition, in 2017, BXCOMP had already been attended by 473 freshmen, along with other 68 students (sophomores, seniors, and MPhil students) who worked as staff, some of them having participated as competitors in previous editions. As staff, students were responsible for formulating 151 programming challenges, under the supervision of four teachers of programming logic and data structures courses. More details about the competition can be found in Table 1, which shows BXCOMP's scope in terms of number of students, teachers, and partners involved in the activity, along with the number of programming challenges formulated and applied during these five years. Tables 2 and 3, in turn, list the technical content addressed in the programming challenges, the courses in which these contents are taught (considering both the curricular program of

[3]Only available in Portuguese.

ISup and the regular knowledge acquired during regular education), and the number of challenges in which each content was addressed in each edition of the competition.

Table 1. BXCOMP historical data, with the year of each edition, number of programming challenges, competitors (and teams), students (and professors) in the staff team, business partners and awards given to the three best rated teams (*Cultura card* is a prepaid card valid in a famous Brazilian bookstore).

ed.	challenges	contestants	organizers	partners	awards
2011	18	57 (15)	10(4)	1	external HD
2012	19	75 (20)	12(4)	1	Kindles
2013	20	58 (15)	13(4)	1	*Cultura* cards
2014	21	53 (14)	12(4)	1	*Cultura* cards
2015	22	75 (20)	18(4)	2	external HD
2016	22	78 (20)	15(4)	2	headphones
2017	29	77 (20)	16(4)	2	*gift/game* cards

Table 2. Programming challenges' content from 2011 to 2014

Courses	Contents	# Challenges by edition				Total
		2011	2012	2013	2014	
Introduction to Programming	Selection structures	18	19	19	20	76
	Repetition structures	18	19	20	21	78
	Vectors/matrices	12	15	19	15	61
	Parameter passing	5	10	7	15	37
	Object-oriented computing	0	0	0	1	1
	Searching algorithms	0	1	0	0	1
	Operations with binary numbers	0	0	0	1	1
Introduction to Analysis of Algorithms	Recursive algorithms	1	0	0	1	2
	Sorting algorithms	1	1	0	1	3
Algorithms and Data Structures I	Stacks	1	0	0	0	1
Discrete Mathematics	Propositional logic	7	6	6	9	28
Matrices, Vectors and Analytical Geometry	Linear combination	0	1	0	0	1
	Matrix operations	0	1	0	0	1
	Straight lines and plans equations	0	0	1	1	2
Mathematics (Calculus) and Statistics	Newton's generalised binomial theorem	0	1	0	0	1
	Probability	0	1	0	0	1
	Fibonacci sequence	0	1	0	0	1
	Prime numbers	1	0	1	0	2
	Geometry	1	0	0	0	1

Since its 2016 edition, the championship began to offer some gymkhana activities in several of its stages. In these activities, teams that achieve certain goals during the rounds earn the chance to compete in extra tasks. These tasks involve the search for information hidden on the campus. The best team in these extra activities wins extra rewards or competitive advantages in the championship. As a result, the activities have increased the range of skills and competencies considered important to students, and have extended the championship's objectives over the socio-technical scope.

4.2. Set-up and Execution

BXCOMP's set-up and execution are in constant evolution since its first edition in 2011. Currently, there are well-defined procedures for each task necessary for setting up the competition's rounds, as well as for supporting the implementation of their activities. The process that must be followed in preparing and executing the competition is shown in

Table 3. Programming challenges' content from 2015 to 2017

Courses	Contents	# Challenges by edition			Total
		2015	2016	2017	
Introduction to Programming	Selection structures	21	22	26	69
	Repetition structures	21	22	27	70
	Vectors/matrices	16	18	20	54
	Parameter passing	14	14	9	37
	Object-oriented computing	2	0	1	3
	Searching algorithms	0	0	0	0
	Operations with binary numbers	0	0	0	0
Introduction to Analysis of Algorithms	Recursive algorithms	0	3	2	5
	Sorting algorithms	0	0	0	0
Algorithms and Data Structures I	Stacks	0	0	0	0
Discrete Mathematics	Propositional logic	9	6	7	22
Matrices, Vectors and Analytical Geometry	Linear combination	0	0	0	0
	Matrix operations	1	1	0	2
	Straight lines and plans equations	0	0	0	0
Mathematics (Calculus) and Statistics	Newton's generalised binomial theorem	0	0	0	0
	Probability	0	0	0	0
	Fibonacci sequence	0	1	1	2
	Number base conversion	1	1	0	2
	Prime numbers	0	0	0	0
	Geometry	0	2	2	4

Figures 2 and 3. This process comprises the analysis, review, update and implementation of each activity in BXCOMP.

The first activity in the preparation phase is the identification of all positive and negative features pointed out by participants during BXCOMP's previous edition. With this information at hand, new procedures are created seeking to improve the competition's quality. The whole process is done by PET-SI students, under the supervision of professors. During the five years covered by this study, the main actions incorporated in BXCOMP's set-up and planning process were:

- Documentation of identified problems and actions, thereby keeping track of the experience gathered in previous editions, so as to help better organize BXCOMP's future editions;
- Continuous update of BOCA's[4] tutorial, considering both competitor and organizer viewpoints;
- Simulation of each round, in an attempt to anticipate and correct problems regarding the programming challenges elaborated by PET-SI's students;
- Continuous revision of the competition's rules, so as to mitigate problems such as improper registration or inadequate behavior by competitors;

The next steps in the preparation phase comprise contacting companies that might be interested in sponsoring the competition, revising and updating the competition's rules, building advertising material and carrying out activities to promote the competition. The participation of companies is particularly desirable to emphasize the importance of collaborative work and programming-related skills in the information technology industry. In order to bring companies closer to students, two strategies are applied: i) company employees are invited to attend some of the competition rounds, to motivate and bring more value to student participation; and ii) company employees are invited to actively participate in the competition, by preparing challenges related to their company's business field.

[4]BOCA is an administration system designed to held programming contests [De Campos and Ferreira 2004], available at `https://www.ime.usp.br/~cassio/boca/`.

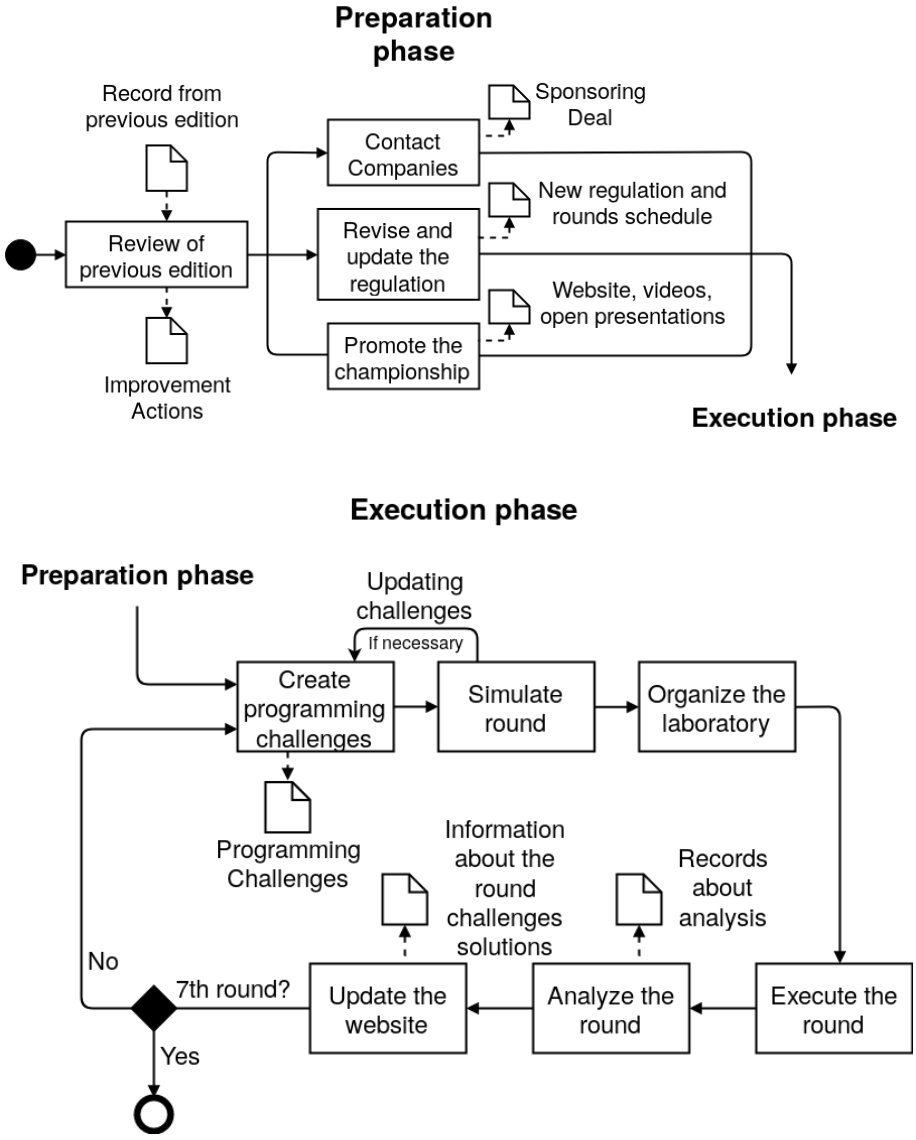


Figure 2. Set-up and execution of each BXCOMP edition.

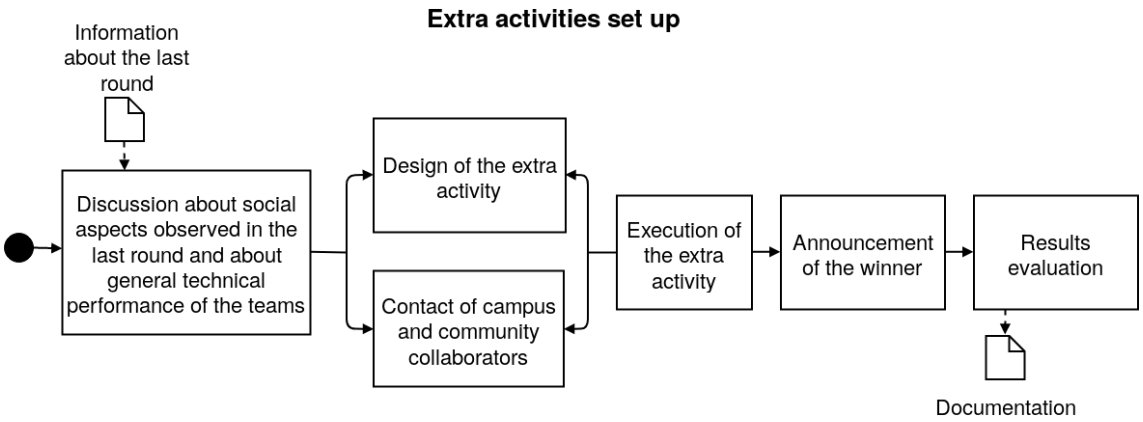


Figure 3. Set-up and execution of extra activities during BXCOMP's rounds.

Under constant change, the competition's rules cover issues regarding student eligibility for the contest, registration process, schedule and scoring, along with rules about the expected behavior by the participants. The most critical and sensitive part of these rules is that related to eligibility and behavior issues, such as:

- How to safeguard the balance regarding competitors' knowledge level: even though only freshmen should be eligible, the University allows students that fail in initial courses to keep their freshmen status. Since they start from higher grounds than their counterparts, they should not be allowed to participate;
- How to build a safe environment in the laboratories where the competition rounds take place: the natural rivalry present in such contests may occasionally lead to euphoric and/or provocative behavior which, if in excess, should be inhibited.

Additionally, the competition's schedule should also be aligned to the curricular activities of competitors and organizers. In order to achieve this goal and maximize students attendance to the rounds, the competition is planned so as to avoid rounds during weeks in which students have an expressive amount of academic work, such as exams and assignment deadlines, also avoiding weeks with holidays.

The last task in the preparation phase is publicizing the activities, which involves posting on social media, sending messages to e-mail lists, conducting open presentation sessions, and announcing the championship in classrooms. This process receives support from undergraduate programs' coordinators, professors and student associations. The main artifact used in this advertisement is a set of videos reporting both the skills developed during activities and the competition's previous editions.

Starting at its 2016 edition, BXCOMP's rounds followed a new procedure (Figure 3), which consists in identifying opportunities to carry out activities to promote the socio-interaction among teams and between teams and the campus community. As an example, the third round of BXCOMP's 2017 edition involved a challenge related to encryption, according to which encrypted messages were hid in some of these challenges' testing cases. The first three teams to discover them were allowed to participate in an extra activity after the round's end. In this extra activity, teams were asked to visit a series of research laboratories and talk to researchers to get some clues about where to find a small souvenir.

During the competition's execution phase, students of the organizing committee are split up in groups with 2-3 students each, taking turns to perform the following activities:

- Programming challenges definition. Programming challenges must be new or adapted from public repositories. The organizers also prepare test cases and program solutions to the challenges (in Java). During these activities, they can assess their level of difficulty, adapting them if necessary. All resulting material is revised by senior undergraduate or mPhil students.
- Round simulation before deploy. During the simulation, organizers play the role of competitors, so as to identify possible issues beforehand, such as misinterpretations, errors or incomplete test cases. Challenges are then updated if necessary.
- Setting up laboratories for the competition. Since the laboratories to host the competition are also shared with other students, all computers must be tested and prepared in advance. The organizers then determine which computers can be used,

reporting any software or hardware problem to the University staff. This activity is carried out the day before each round.

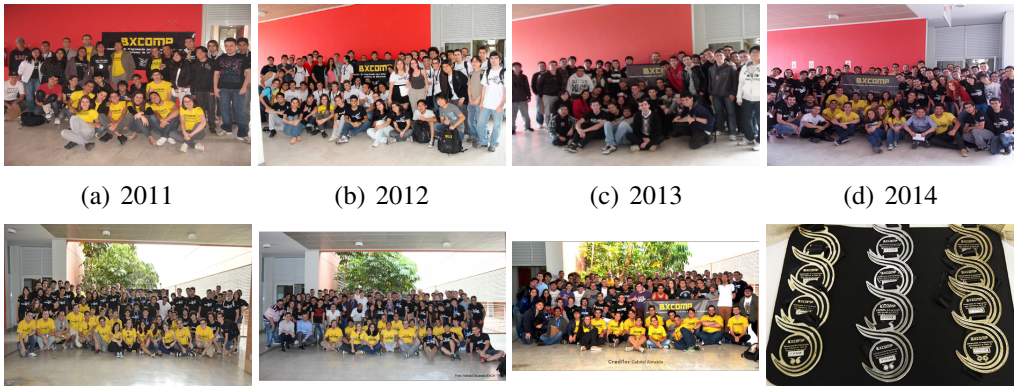
- Round management. PET-SI students must distribute competing teams among computers, organize balloons (teams must blow a balloon out every time they solve a challenge), build scoring tables, connect computers to the BOCA system, control the access to laboratories, supervise competitors and solve any computer related problem. Figure 4 shows the laboratory environment during a round.

(a) (b)

Figure 4. Laboratory environment during one round

After each round, staff students and professors meet to discuss issues related to software, hardware or other infrastructure problems (which, in turn, are either reported to the university staff or used to create new procedures for contest management); to challenges (which are analyzed in depth so their causes can be determined); to the competitors' behavior and performance (to respond to cases of problematic behavior and to analyze the round's real difficulty level); and to organizers' behavior and performance (so as to verify whether they acted correctly in different situations and, if necessary, give them orientation).

During the last round, all students (both competitors and organizers) are congratulated by professors and industry professionals, who also perform a brief awards ceremony in which the three winning teams are announced and awarded with official competition medals and some gifts offered by sponsors. Figure 5 shows some snapshots of each edition's final celebration, along with a picture of the official medals.



(a) 2011 (b) 2012 (c) 2013 (d) 2014

(e) 2015 (f) 2016 (g) 2017 (h) Medals

Figure 5. Final celebrations and official medals

5. Conclusion

BXCOMP has been successfully carried out for seven years and, currently, it is part of the official extracurricular program of the Information Systems undergraduate course at the University of São Paulo. Freshmen become aware of the championship's existence in the early weeks of classes. During the championship's editions, professors involved in their organization and those teaching programming classes observe students' involvement in the championship and their technical evolution in the classroom. In general, the perception is that of an increase in students' knowledge in the area of programming. From the point of view of the students who organize the championship, there is also an evolution in their programming skills, since during the championship they have the opportunity to experience programming teaching tasks, deal with the analysis of the level of difficulty of programming challenges during their elaboration, the need to develop writing skills, and the need to develop advanced software testing cases. Finally, it is the opinion of the professor tutoring these PET-SI students that they have also gained maturity, since they were involved in an activity that requires discipline, critical sense and responsibility.

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