Principles of agile project-based learning to cope with the computer programming education at Brazilian Information System higher education

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ABSTRACT

Teaching and learning of computer programming (TL-PROG) is a fundamental subject to System Analysis Bachelor and related graduation courses. In general, teaching programming using traditional methods has become much more challenging due to many reasons. It includes changes in the manner new generations are prone to learn and the arising of new programable devices. In this context, Project-Based Learning may offer potential benefits to TL-PROG, mainly Agile Project-Based Learning (APjBL). However, there are a few relevant studies relating PjBL and TL-PROG in Brazilian. Therefore, we propose to analyze the benefits of the APjBL when compared to the traditional Brazilian TL-PROG. As the comparation criteria, we propose to evaluate the benefits to students' grades, motivation, communication and profession.

CCS Concepts

Social and professional topics → Professional topics → Computing education.

Keywords

Computer Programming, Teaching Methods, Project-based Learning.

1. INTRODUCTION

Regarding Information Systems (IS) and related Computer Science education programs, some recent researches have been reported challenges such as a high level of students' evasion and fail. These challenges seem to apply at both developed and underdevelopment countries and indications of a lack of interest in SI by new entrants. In this context, computer programming is a fundamental area. However, teaching and learning of computer programming (TL-PROG) is also very challenging. Some additional difficulties make this scenario even more complex: changes in the manner new generations are now prone to learn programming; high level of evasion at introductory programming courses; new programmable devices [1,11,15,20,24,26] .

In order to enhance the computer programming education, there are at least three relevant aspects: (i) the teaching methods, (ii) the students' grade and (iii) the student's motivation to learn (from now on, referred as motivation). Improvements on the teaching methods are usually know to be related with improvements on students' performance. Thus, Project-Based Learning (PjBL) might be used as an alternative teaching method, given its effectiveness when compared to the traditional teaching methods. Among different PjBL approaches, the APjBL tends to be more effective to the TL-PROG context given its simplicity, adaptability and its own origins from software developement [6,14,16].

Althought PjBL may help students to improve their grades and motivation in TL-PROG, this reseach identified via a systematic literature review (SLR) that a few relevant reports came from Latin America context. Given these basis, the main research objective is: to analise the benefits of APjBL principles applied to the computer programming education when compared to the traditional education, in the Brazilian SI undergraduate context.

The remainning of the research is as follows. Section 2 describes the research problem. Section 3 presents the proposed solution. Section 4 addresses the solution evaluation. Section 5 report the partial results. Section 6 presents the research conclusion.

2. PROBLEM DESCRIPTION

Students may struggle to learn computer programming Due to many reasons, given TL-PROG is still considered very challenging for both students and educators. TL-PROG is also considered complex and very mental demanding task from students' perspective. It requires a long learning curve. All these challenges might results in high evasion rate, such as those found at introductory programming courses [1,8,11,15,20,26].

There have been found reports that PjBL enhances students grades and motivation in computer programming contexts. PjBL classes are bounded by real-world challenges and also by collective knowledge. Besides, PjBL might help students to deal with a second foreign language, such as the context found in Latin America IS courses [9,20,25,27].

Anyhow, applying PjBL to the TL-PROG may not be a standard or straight forward process. Therefore, we propose to join three different aspects, as follows: #1, the education aspect; #2, the project management aspect and #3 the PjBL outcomes and benefits. The merge of these three aspects were grounded by several studies [3,7,10,12,14,16,18,19,21] and are summarized into Figure 1. These are base concepts used by this research, as follows:

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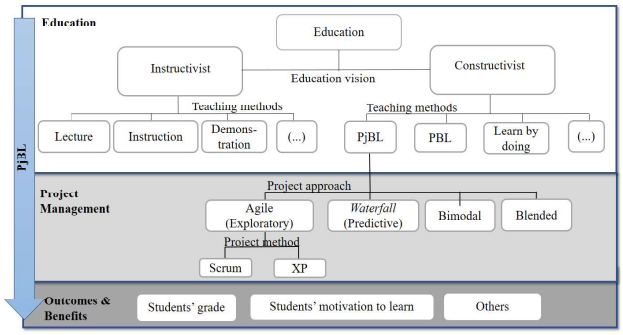

Figure 1. Base concepts adopted by this research.

On figure 1, the first aspect is education. In the need of defining traditional and non-traditional education, we chose to classify teaching methods under two distinct education visions (or metaphors): the instructivist and the constructivist visions. These metaphors help people understanding the education big picture. Instructivist vision is also known as professor-centric approach, in which knowledge is mainly passed via instructions to the students, such as lectures. The constructivist vision states that students construct their own knowledge, such as PjBL or problem-based learning (PBL) methods. Anyhow, education process is usually a gradient set into middle points of this *continuum*.

The second aspect relates to the project management, in which there are both project methods and project approach. Many of them were created asides the education environment such as project approaches (such as Agile, Waterfall or Blended) and its related project methods. Thus, choosing PjBL as TL-PROG education method implies the need to bind process of project management and education.

The third aspect relates to outcomes & benefits, come from both education and business projects lanes. Regarding education projects, students' grades are the most common outcomes from any course. Other additional students' outcome might relate to non-grades measures, such as motivation.

3. PROPOSED SOLUTION

This work adopts the explicative research with quali-quantitative (also known as mixed) analysis. This choice was based on the interest of understanding the phenomenon - PjBL benefits - and its relations with two or more variables, mainly students' grades and motivation. This approach is relevant to multidisciplinary contexts, where qualitative and quantitative data give each other mutual support. Thus, this research adopts the educational quasi-experimental to be executed *in locus,* i.e., at a real university and a real semester [2,5,22].

The main objective of this research was split into four specific objectives. **SO1:** Identify and describe the project methods and project approaches that are related to both PjBL and TL-PROG, including the most suitable approach or method to the Brazilian context. **SO2:** Identify the impact on students' grades and motivation after the use of PjBL as an alternative programming teaching method. **SO3:** Identify the benefits students may experience when learning programming via PjBL. **SO4:** Compare the traditional programming classes with APjBL principles classes at Brazilian Information System higher education by analyzing the benefits to the students during a semester, specially their grades and their motivation.

Based on findings produced by a SLR (Systematic Literature Review) [13] executed by this research, AMoPCE (Agile Model for Projects in Computing Education) [12,21] was chosen as the most suitable APjBL method to this research. AMoPCE is a teaching method that simplified Agile most relevant principles and applied them to computer education, thus resulting a supportive teaching method. All principles are described in details at the original research but the figure 2, adapted from the original research [12], presents an overview of AMoPCE principles:

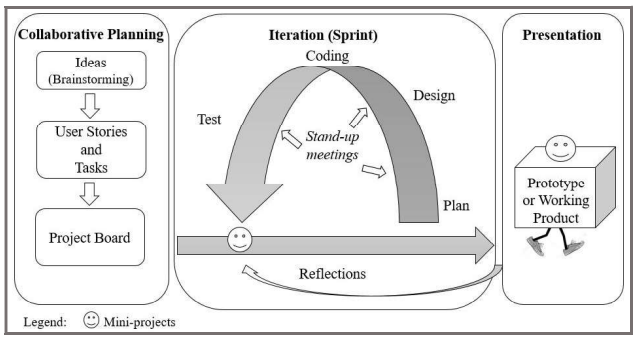

Figure 2. AMoPCE adapted from [12]

AMoPCE was adapted by professors to a substantial degree according to the teaching and learners needs [12]. Thus, at this research, professors will also be able to adapt the most suitable principles of agile project-based learning to their programming courses to cope with the computer programming education. In order to make principles more understood and applied by the professors, there were split into seven Agile principles [12,21], as follows:

(1) **Collaborative Planning**: lane that includes the planning activities of AMoPCE: the generation of ideas, the planning the user stories and their related tasks. The trackin of tasks and deliverable might be tracked by a project board.

(2) **Iteration** (Sprint): The iteration, also referred as sprint, is consider a core value from Agile methodology. This is a small chunk of time, usually between one to three weeks, in which it occurs the development of the planned software [23]. The activities follow the plan, design, code and test sequence.

(3) **Presentation**: mini-project should be reviewed collaboratively whenever as possible. Additionally, based on Agile principles, it is encouraged the inclusion of non-punitive assessments named as reflections.

(4) **Standup meeting:** also know on Scrum as Daily Scrum, this Agile principle is a short 10 to 15 minutes meeting, in which all members standup to report what they did, what they plan to do today, and what are the issues and difficulties [23].

(5) **Pair programming:** Agile principle the two people join together to solve a programming task or challenge. One stay leading the computer and discussing, while the other one give directions and suggestions. After a certain point, they change position.

(6) **Keep it simple:** Principle of doing the simplest solution to achieve the objective [23]. Regarding the education aspect, it regards to learn from simplest to more complex contents, choosing the simplest code implementation and similar.

(7) **Planning Poker:** a quick collective game in which all participants give their best estimate to challenge, usually the estimation of tasks during the planning phase.

This is expected that AMoPCE principles will be blend with other practices and methods thus resulting in a blended APjBL method.

The SLR also indicated that main benefits of the PjBL to students are grades, motivation, as well as communication and profession. Thus, the research question resulted in four leading hypotheses, regarding the benefits of AMoPCE to the students, as follows. **H1:** AMoPCE benefits students' grades. **H2:** AMoPCE benefits students' motivation. **H3:** AMoPCE benefits students' communication and **H4:** AMoPCE benefits students' professional aspects. Therefore, the dependent variables and instruments are, respectively to each hypothesis: (H1) grades results; (H2) motivation to learn; (H3) communication; (H4) professional aspect (to be defined). All on Likert scales.

In order to verify the research question and its hypotheses, the experiment was design using seven phases, according to figure 3:

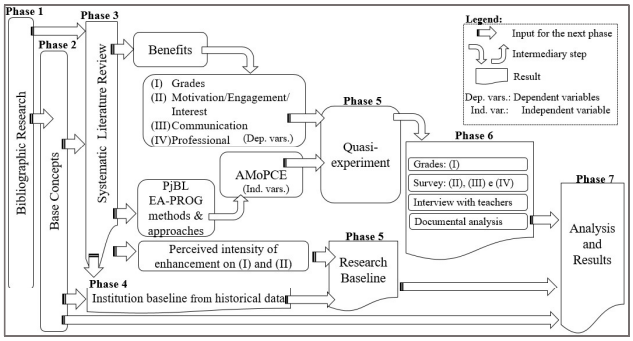

Figure 3. Research phases diagram.

On phase 5, there will be two groups participating to the quasi-experimental: first, the experimental group will be subjected to APjBL principles; second, the comparison group will learn programming according to the Institution traditional TL-PROG.

4. SOLUTION EVALUATION

The researched Institution is located at the surroundings of the Campinas city, São Paulo state, Brazil, and therefor will represent the Brazilian context. Given the resources and time constraints that are naturally applied to a Master Thesis, the scope of this proposal is limited to be applied to the referred *campus* only. The scope might be extended to the Brazilian and Latin America contexts in a near future during a Doctoral phase. Additionally, the Researched Institution has other *campi* across São Paulo state and Brazil, which may support possible future researches.

The programming courses are part of a technological higher education named as Analyses and Development of Information Systems (our translation). In order to evaluated these impacts, AMoPCE will be applied to programming courses by professors who may voluntary contribute to this research. Given the time and resources constraints, a suggested by [12], collective and individual workshops will be conduct with the professors, in addition to the research documentation. And each professor will be supported constantly by the researcher during the entire research.

On phase 6, there will be collected data from students, from professor and from historical data, as follows. Regarding students' data, the will be collect via an electronic survey, as close as possible to the end of each course. The data will be acquired from both the experimental and comparison groups. Surveys will be adapted from the following studies: motivation to learn, from [4]; communication, from [17]; professional (still to be defined), thus been one of the intended contributions of this work. Students' data will result into quantitative measures. On the other hand, professors' perspectives, including their observations about the three non-grading measures, will be collected via a semi-structured interview, thus resulting into qualitative data.

Phase 7 will have descriptive and inferential results based on phase 6 results. The evaluation will occur in four steps. First, the quantitative data will subject to descriptive statistic; content analysis will address the qualitative data. Second, it will be used Analysis of Variance (ANOVA) and statistic regression, to test the hypotheses and may generalize the phenomenon. Third, the qualitative data professor interview will be analyzed via context analysis. The interviews, together with the historical data, will substantiate or not with the quantitative findings. Fourth the final result will be consolidated and published. Other adopted evaluations used by this research are described in the next section.

5. COMPLETED ACTIVIES

Phases 1 and 2 were mainly developed during 2017 as part of this Master Thesis. They serve as foundation for the following phases. Phases 3 and 4 were conduct separately and they were submitted to relevant Congresses. Phase 5 is planned to start on Mar 2018 and the research is planned to end on Jan 2019.

Phase 3 was a SLR [13], in which the specific objectives SQ1, SQ2 and SQ3 where achieved. The SLR also provided a baseline to the phases 4 and 5.

On phase 4, there was a comparative study between the instructivist and constructivist methods based on the historical data of the researched Institution. It was collected longitudinal data from 154 students, from 2015 to 2017, regarding the courses web development levels 1 (novice) and level 2 (advanced). Given ANOVA at 5% confidence level, the finding points show that the more constructivist the classes went at the education *continuum*, the more the students' grades were enhanced. Regarding motivation, in the absence of any historical data about it, it was used the students' classroom frequency as an approximate (but still partial) measure. The findings pointed out that more constructivist classes did not impact their motivation (frequency).

6. CONCLUSION

Nowadays innovation is very demanding at IS courses and related technological education. In this context, APjBL may offer many benefits to both students and teachers. This research looks for the benefits of APjBL, based on AMoPCE principles, applied to the Brazilian Information System higher education, mainly benefits to the students' grades, motivation, communication and professional aspects.

In finding benefits to students, such as grades, motivation, communication and professional, these principles might be applied on similar contexts and benefit future programmers. There are indications that APjBL may benefit IS computer programming and the academic routine as well. Future researches might also investigate the impact of APjBL at developing countries given their particular settings. After all, the revolutionary Agile methods started benefiting the software programming environments.

7. REFERENCES

[1] A. Abdool and A. Pooransingh. 2015. An industry-mentored undergraduate software engineering project. In *Proceedings - Frontiers in Education Conference, FIE.* DOI:https://doi.org/10.1109/FIE.2014.7044180

[2] J. Bell. 2005. *Doing your research project: a guide for first-time researchers in education, health and social science.* DOI:https://doi.org/10.1111/j.1467-8535.2006.00650_12.x

[3] J. B. Biggs and C. So-kum Tang. 2011. Teaching for quality

learning at university. In *SRHE and Open University Press imprint* (4th ed.). McGraw-Hill Education, New York, USA, 1–16.

[4] E. Boruchovitch. 2008. Escala de Motivação Para Aprender de Universitários: Propriedades Psicométricas. *Avaliação psicológica* 7, 2 (2008), 127–134.

[5] J. W. Creswell. 2009. Mixed Methods Procedures. In *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (3rd ed.). SAGE Publications, Thousand Oaks, 203–226.

[6] G. C. Gannod, Douglas A Troy, Jerome E Luczaj, and Diane T Rover. 2015. Agile Way of Educating. In *Frontiers in Education Conference (FIE), 2015* (Frontiers in Education Conference), 10–12.

[7] Gartner. 2017. What is Bimodal IT? See Gartner's IT Glossary For The Answer. . 13–18. Retrieved August 14, 2017 from https://www.gartner.com/it-glossary/bimodal

[8] L. M. M. Giraffa, M. C. Moraes, and L. Uden. 2014. Teaching Object-Oriented Programming in First-Year Undergraduate Courses Supported By Virtual Classrooms. In *The 2nd International Workshop on Learning Technology for Education in Cloud*, Lorna Uden, Yu-Hui Tao, Hsin-Chang Yang and I-Hsien Ting (eds.). Springer Netherlands, Dordrecht, 15–26. DOI:https://doi.org/10.1007/978-94-007-7308-0_2

[9] T. Goulding. 2013. A first semester freshman project: The enigma encryption system in C. *ACM Inroads* 4, 1 (2013), 43–46. DOI:https://doi.org/10.1145/2432596.2432613

[10] A. Hernandez-Barrera. 2014. Teaching introduction to robotics: Using a blend of problem- and project-based learning approaches. In *IEEE Southeastcon 2014* (IEEE SoutheastCon-Proceedings).

[11] M.Iskander. 2008. Innovative Techniques in Instruction Technology, E-learning, E-assessment and Education. . Springer Netherlands, New York, 199–203.

[12] P. Kastl, U. Kiesmüller, and R. Romeike. 2016. Starting out with projects - Experiences with agile software development in high schools. In *ACM International Conference Proceeding Series*, 60–65. DOI:https://doi.org/10.1145/2978249.2978257

[13] B. Kitchenham and P. Charters. 2007. A systematic review of systematic review process research in software engineering. *Inf. Softw. Technol.* 55, 12 (2007), 2049–2075. DOI:https://doi.org/10.1016/j.infsof.2013.07.010

[14] G. Lang. 2017. Agile Learning: Sprinting through the Semester. *Inf. Syst. Educ. J.* 15, 3 (May 2017), 14–21.

[15] M. Liston, D. Frawley, and V. Patterson. 2017. A Study of Progression in Irish Higher Education. 23–24. Retrieved from http://hea.ie/assets/uploads/2017/06/A-Study-Of-Progression-in-Irish-Higher-Education-201213-201314.pdf

[16] D. Monett. 2013. Agile Project-Based Teaching and Learning. *Proc. Int. Conf. Softw. Eng. Res. Pract.* (2013), 1.

[17] C. Morimoto. 2016. Improvement of IT Students' Communication Skills using Project Based Learning. In *Proceedings of the 8th International Conference on Computer Supported Education*, 147–152. DOI:https://doi.org/10.5220/0005891501470152

[18] C. R. Payne. 2009. Information Technology and Constructivism in Higher Education: Progressive Learning Frameworks. . IGI Global, Hershey, PA, USA, 1–25.

[19] D. Porcaro. 2011. Applying constructivism in instructivist learning cultures. *Multicult. Educ. Technol. J.* 5, 1 (2011), 39–54. DOI:https://doi.org/10.1108/17504971111121919

[20] R. Queirós. 2014. Innovative Teaching Strategies and New Learning Paradigms in Computer Programming. . IGI Global, Hershey, PA, USA, 131–133.

[21] R. Romeike and T. Göttel. 2012. Agile projects in high school computing education - Emphasizing a learners' perspective. In *ACM International Conference Proceeding Series*, 48–57. DOI:https://doi.org/10.1145/2481449.2481461

[22] R. H. Sampieri, C. F. Collado, and P B Lucio. 2006. Modelos de Pesquisa. In *Metodologia de pesquisa* (3a ed.). McGraw-Hill, São Paulo, 152–223.

[23] K. Schwaber and J. Sutherland. 2013. The Scrum Guide. *Scrum.Org and ScrumInc* July (2013), 17. DOI:https://doi.org/10.1053/j.jrn.2009.08.012

[24] R. L. L. e Silva Filho, P. R. Motejunas, O. Hipólito, and M. B. C. M. Lobo. 2007. A evasão no ensino superior brasileiro. *Cad. Pesqui.* 37, 132 (2007), 641–659. DOI:https://doi.org/10.1590/S0100-15742007000300007

[25] M. Thomas. 2017. Project-Based Language Learning with Technology: Learner Collaboration in an EFL Classroom in Japan. In Routledge (ed.). Taylor & Francis, New York, USA, 43–47.

[26] C. Vega, C. Jiménez, and J. Villalobos. 2013. A scalable and incremental project-based learning approach for CS1/CS2 courses. *Educ. Inf. Technol.* 18, 2 (2013), 309–329. DOI:https://doi.org/10.1007/s10639-012-9242-8

[27] E. Zouganeli, V. Tyssø, B. Feng, K. Arnesen, and N. Kapetanovic. 2014. Project-based learning in programming classes – the effect of open project scope on student motivation and learning outcome. *IFAC Proc. Vol.* 47, 3 (2014), 12232–12236. DOI:https://doi.org/10.3182/20140824-6-ZA-1003.02412