Detailing an e-Learning Course on Software Engineering and Architecture Using BPMN

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Abstract

We have employed BPMN diagrams to expose the foreseen teaching and learning activities of participants in an e-learning course under planning. This provided clarification of the teaching and learning actions, revealing to the educational planning team aspects which were not explicit in the lecturer's plan, such as: the level of effort for the teacher as well as for the student; specific moments when there is a need to provide feedback and motivation. We believe that this exercise constitutes a rich and helpful contribution in planning and visualization efficient for other teaching teams of computer programming courses.

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1 Introduction

Planning the educational process is key for effective course preparation [9]. However, most educational planning focuses syllabus content of the syllabus, not rendering explicit actual activities expected of teachers and students throughout the semester, even though that's what really matters and leads to learning [5]. We sought to render them explicit, a necessity in online contexts, due to their different interaction dynamics, where there is a significant challenge to achieve adequate pedagogical design that is effective [14]. For this, we revised a course plan laying out expected actions from all involved parties (teacher, students, information systems). The outcome revealed hitherto unexpected complexity in actual tasks, enabling us to decide on improvement measures. In this paper, we exemplify this approach, towards increased perception by educational planners (e.g., learning designers, teachers, program supervisors, e-learning platform managers) of the benefits of BPMN (Business Process Model and Notation) [7] to reveal which activities are expected of involved parties. This visual notation renders explicit interactions, communications, and actions of the parties, enabling reflection upon it to identify improvement targets: bottlenecks, workloads, decision-making with insufficient information, unforeseen tasks, etc. The course under scrutiny was "Software Development Laboratory", part of the undergraduate program on Informatics Engineering at Universidade Aberta, Portugal's public online learning university. Within the next two sections, we provide an overview BPMN concepts and previous efforts to employ it in education and the course context. In subsequent sections, we provide two exemplary cases of educational activities described with BPMN, through which reflection was enabled upon aspects unforeseen in traditional course planning. We conclude by highlighting how this process can also contribute to ascertain informational and technical support needs of the involved parties. The identification of such needs enables individuals to acts to better manage the associated workload and may contribute to the development of more effective learning and teaching support tools.

2 Related work: BPMN in educational planning

In online education, students are typically working at their own pace through the materials, and interactions are generally asynchronous. What makes it challenging is that the teacher must depart from usual experiences of physical, face-to-face interactions towards new teaching methods, which require greater focus on time management. This implies planning learning activities that rely on students' autonomy and initiative - and that align with an older target audience (typically mid-20s onwards, over several decades of age range), and that are deployable with large virtual class sizes [8]. These stricter educational planning needs can benefit from BPMN, a process-description graphical notation [7]. It enables exposing roles and interactions of stakeholders with learning activities [2], supporting answering questions such as "Why is it done? By whom? Where? When? How is it performed?". Its use in modelling and managing e-learning processes aims to facilitate their development and maintenance [12]. The literature provides a diversity of examples: planning software engineering hands-on classes for maturity and appraisal process analysis [13]; analysing interactions and activities in learning processes [1]; or visualizing train-the-trainer sessions in blended environments [6]. In general, the ability of BPMN to support a clear understanding of the interconnection of learning stakeholders throughout processes enables the identification of improvement potential, such as discussing possible intervention points and reasonable activities [3].

3 The course context

The course "Software Development Laboratory" (LDS, Portuguese-language acronym) has an online asynchronous e-learning format, in the Moodle platform, during the 2nd semester of the 2nd year of the Informatics Engineering undergraduate program of Universidade Aberta (UAb), Portugal, over 12 academic weeks. Its goal is to scaffold undergraduates in their transition from novice programmers into proficient programmer, pursued over a six-topic syllabus. Since it is asynchronous, no specific schedule exists for fulfilling activities. Students complete them at their own pace and within their own schedule, within deadlines. Discussion with the teaching staff and colleagues is also done asynchronously. This temporal flexibility is mandated by UAb's pedagogic model, which states it as a cornerstone [11]. The rationale includes the fact that UAb's students have typical demographics of online education: 30-50 year-old adults, with scheduling constraints of active professional careers and the need to care for children/teenagers or older relatives; and disseminated across the globe, with wildly varying timezones. Thus, during the two-week span of each topic, the teacher must track and encourage progress and interaction, since any procrastination until the final days of the span will lead to lack of opportunities for teacher and/or peer feedback. LDS has been the field for pedagogic experimentation of the software engineering didactic approach SimProgramming [10], created for a physical classroom course with similar goals.

4 Exemplary cases in BPMN

BPMN modelling revealed unexpected complexities in apparently simple tasks in the LDS course. Here we present two exemplary cases, resulting from interactive collaborative design of the BPMN diagram, involving the course lecturer, a didactics researcher, and two educational technology researchers.

4.1 Case one: viewing a slideshow

Viewing a slideshow is possibly as plain a situation as any one could expect in e-learning: the course provides it, students watch it, the teacher checks progress, and the learning situation is complete. However, process analysis reveals a more complex - and time-demanding - reality. Fig. 1 presents this activity in BPMN, focusing on the teacher's activities (the student tasks likely trigger further actions, such as studying references materials, etc.). There are in all 16 activities, distributed between the teacher, the learning management platform, and the students. The plainer view is reflected by the leftmost activities: the students watch the slideshow, the learning platform collects data on this, generates graphics and reports, and the teacher views them. If a student views the slideshow timely, its simple task is to report completion and later check if due credit/assessment was granted. The diagram however reveals the complexity and workload hidden in the deceptively simple earlier sentence "the teacher checks progress" - which comprises 10 of the total 16 activities. Firstly, students must be encouraged to view the slideshow, in case they haven't already. This is a Goldilocks scenario: not too early, not too late, not too often, just the right amount [4]. This takes place over two weeks, a period during which two reminders or encouragement should occur: first after five days (before the first weekend, prime study period for older adults). The second two days before the end of the period, as a final, personalized effort to encourage participation From the teacher's perspective, these two specific moments involve a specific workload. Actual reminders must be set. Then on the first moment the class encouragement must be posted, and on the second moment the teacher needs to check which students haven't

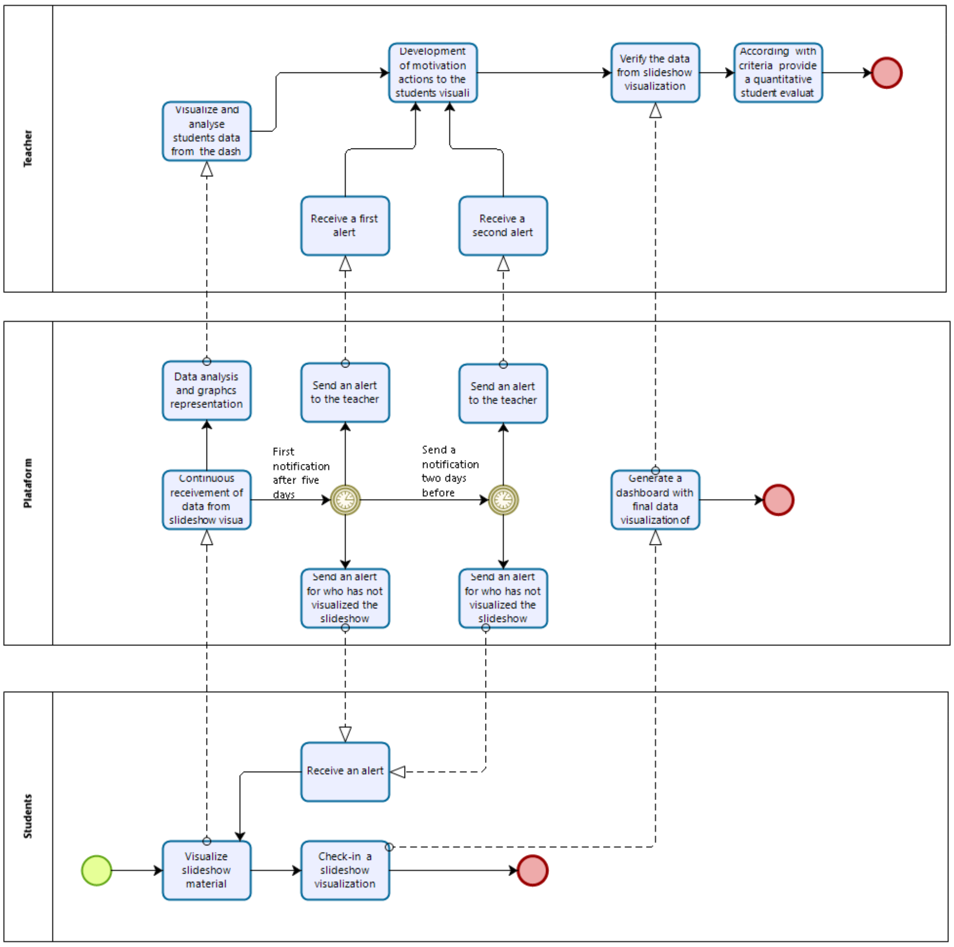

Figure 1 Activity diagram of slideshow visualization process.

yet viewed the slideshow, to send personalized messages. This workload emerges from the BPMN diagram as moments to reserve appropriate time and avoid forgetting. Further, the diagram includes a larger task amidst those moments: "Development of motivation actions to the students visualization". Those motivational actions are diverse, and may include monitoring viewing patterns, comparing them with individual students' class participation habits, considering other parallel tasks in the same course for the same period, etc. The BPMN has framed the scope of this task as that occurring between set reminders, clarifying for the teacher reflection and planning needs that it involves.

4.2 Case two: discussing the syllabus

The PUC document (course plan, Portuguese-language acronym) is similar to a syllabus, providing goals, content, deadlines, assessment methods, and study workload plan for the semester. All students are required to debate it asynchronously for clarifications or changes. Managing such interactions is a demanding task for the teacher, having to track all student postings or lack thereof, establish whether feedback and encouragement are required or not. It is not a clear-cut decision: students may be straying too far off from effective approaches, or even pursuing a misconception, which may require prompt intervention; or they may need to develop autonomy and feel encouraged by peers. Students may not be posting due to a variety of reasons, requiring different kinds of encouragement. They could be planning on working over the weekend, in which case a simple Friday reminder would be adequate; or they could be overwhelmed by preliminary readings, in which case a more personal tutoring style would be adequate; or yet other situations. All these need a teacher's time and attention, which when managing several discussions and courses, can be overwhelming. An example of BPMN analysis of discussion activities is shown in Fig. 2 for the PUC document. Since all students should discuss, participation tracking is geared towards issuing alerts and providing context-relevant data and activity support to different stakeholders. Most students will not participate right away. While some may have a moonlighting schedule, others concentrate coursework over weekends, with evenings devoted only to the most pressing activities. However, if no students participate at all, this will be discouraging: it is necessary to "break the ice" of the dynamics. So for the first few days, the teacher focuses on the overall participation level: if it remains low, issues a global encouragement. Nearing the weekend prime study time, if global participation remains low, a reminder is appropriate. By Monday (day 8), the teacher checks for participants that have not yet acted and sends them individual encouragement messages. Also, per UAb's pedagogic quality standards, any feedback must be provided within two working days, so by day 10 the teacher must provide any due feedback. As the final weekend nears, the final opportunity for timely participation in the activity, the teacher should escalate and send personalized messages to inactive students, considering each individual's status and history, with encouragement, advice on possible consequences of not reading the course plan (lack of awareness of workload, losing an opportunity to contribute to assessment methods, etc.). Throughout, the teacher analyses participation data, to decide on the course of action. We identified three continual data analysis tasks: overall participation; individual participation; queries feedback needs. These are encapsulated in Fig. 2 as "Data analysis". A fourth data analysis task occurs on day 12: in order to provide personalized feedback, the teacher must analyse each non-participating individual's status and history.

5 Discussion

The starting point for the modelling of the educational process within the LDS course were the tasks foreseen for the teacher and students, in the original (traditional) planning. During the process of BPMN modelling of the course, gaps organically emerged: i.e., situations where decisions had to be made but no explicit teacher action was foreseen beforehand, and similar situations. Either the visual diagramming process would not be able to proceed or it would display empty sections without actions between decision-based events. That is to say, the analysis required for BPMN identified shortcomings in the earlier outcome of the traditional course planning. This clearer perspective on the teacher's actions that achieved through the process of BPMN diagramming enabled us to check with more rigour the teaching workload required to maintain the intended pedagogical intervention quality of the planned course activities. This outcome is consistent with that of the Brazilian team reported in the background section [12]. Also, this clearer perspective on the teaching workload can empower teachers to adjust their efforts or develop customized tools to support that workload. Specifically, since decision-making moments are explicit, this contributes to identifying which data must be collected in order to make those decisions. Also, since outcomes are also explicit, it is possible to prepare in advance some supporting instruments, such as feedback templates, rubrics, etc. From the analysed cases, for instance, we can identify the following data needs and design supporting instruments:

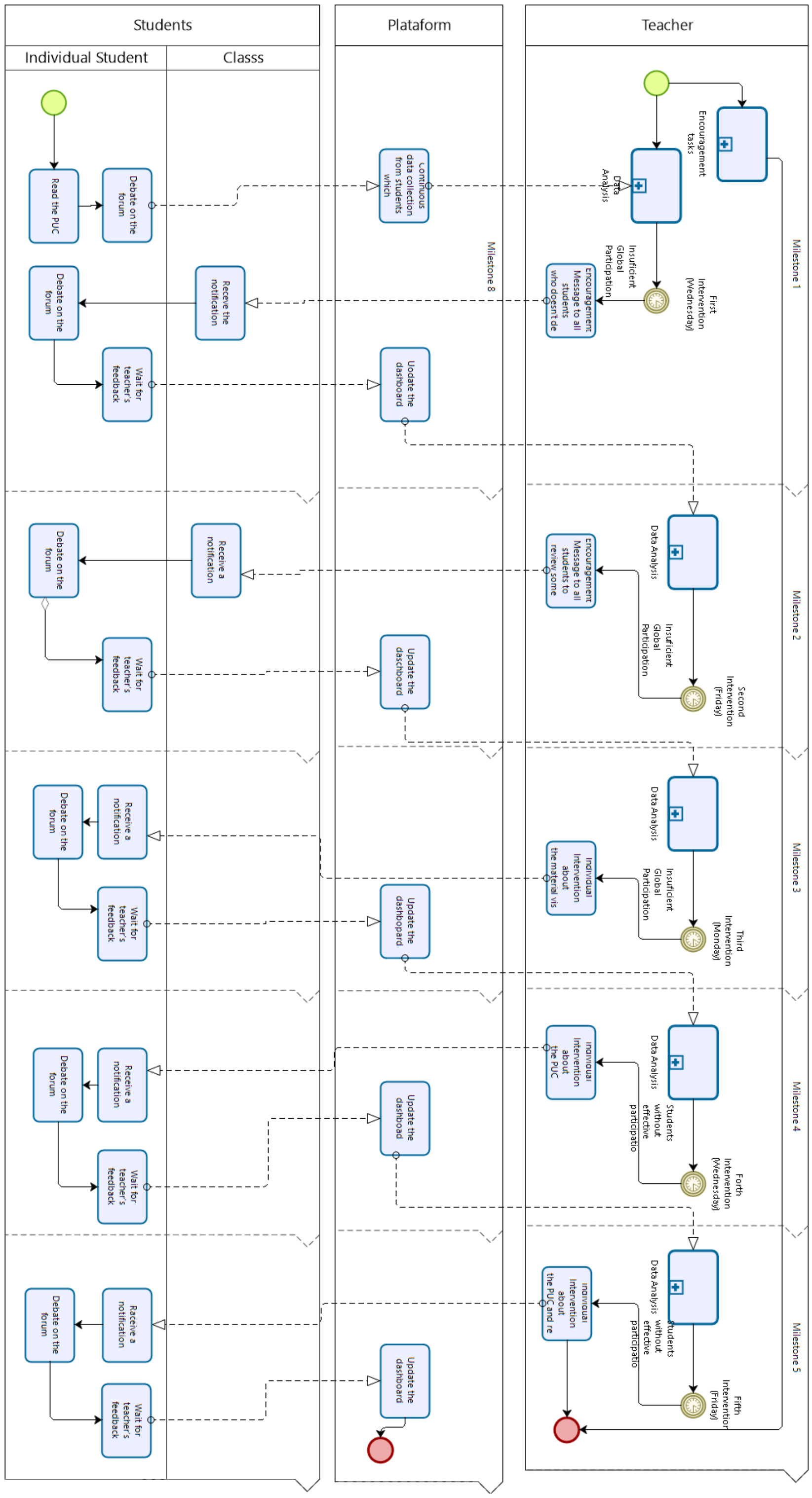

Figure 2 BPMN diagram of tasks for visualization and participation in PUC forum.

- data need: overall participation level;
- supporting instrument: reminders upon deadline of scheduled tasks;
- supporting instrument: templates/rubrics to expedite feedback preparation and drafting;
- data need: list of students requiring day-8 individual messages;
- data need: list of students requiring day-12 personalized messages, containing each individual's status and history.

These data needs and supporting instruments can be developed independently by the teacher, resorting to various freely available tools. They can also be employed by software development teams to craft automated support features in the learning platforms. The crucial aspect was their identification, achieved via the modelling process. Other data needs, expectations, assumptions, and support needs may emerge through model development, since it enables the identification of collaboration possibilities and requirements between the involved parties, their connections, the activities in which they participate, and their responsibilities. As an example, when analysing data provided by the platform, the teacher may establish the need to respond to students queries, check the overall level of student participation within an activity, or identify individual participation. With those data, the teacher will be able to decide, throughout the course, on whether encouragement is necessary, whether teamwork is actually progressing, if there is mutual cooperation, and other factors relevant for active strategies such as SimProgramming [10]. Finally, BPMN modelling of course modules may contribute to streamline modelling of other modules or courses, since patterns may emerge to be replicated readily. This streamlining may contribute towards quick dissemination of these benefits to entire courses, programmes or even institutions.

6 Conclusions

The use of BPMN revealed the activities of the various parties involved in the course: teacher, students, and technological platform. Revealed aspects, tasks, and workload, often implied, not explicit. This makes it a promising tool and approach to support the planning process. The BPMN specification of the course planning helped identify and define concrete occasions for critical interventions: when to provide specific, individual and encouragement feedback, and which data to support that is available for the teacher and from the platform. This enhanced perspective exposed an unexpected level of complexity amidst the interactions between the various parties and their level of coupling. The clarification of the processes that occur enabled us to design strategies to promote self-regulation and co-regulation, identifying required interventions, their opportunity, and the involved parties.

7 Future work

Reflecting upon this experience using BPMN, we are considering its potential as a tool for identifying specific alternatives for better teaching action. It may provide a significant contribution towards didactic and operational re-engineering of courses (i.e., leading to the development of different pedagogical approaches, tools, and interventions), and towards more adequate, more effective educational planning. We are also considering its potential to support the implementation of self-regulation and co-regulation strategies, by supporting students' academic participation and study planning, which contribute towards success. Thus, we suggest expanding this work by using BPMN to specify higher-order educational tasks, more complex and demanding at the cognitive and operational levels than the ones presented herein. Such research may be fruitful for identifying processes and interventions that hitherto where not clearly foreseen in traditional planning.

References

1 S. Azouzi, Z. Brahmi, and S. Ghannouchi. Customization of multi-tenant learning process as a service with Business Process Feature Model. *Procedia Computer Science*, 126:606–615, 2018. doi:10.1016/j.procs.2018.07.295.

2 S. Azouzi, S. Ghannouchi, and Z. Brahmi. Modeling of a Collaborative Learning Process with Business Process Model Notation. In *Digital Economy. Emerging Technologies and Business Innovation*, volume 290, pages 95–104. Springer International Publishing, Cham, 2017. doi:10.1007/978-3-319-62737-3_8.

3 P. Bitzer, M. Söllner, and J. Leimeister. Design Principles for High-Performance Blended Learning Services Delivery: The Case of Software Trainings in Germany. *Business & Information Systems Engineering*, 58(2):135–149, April 2016. doi:10.1007/s12599-015-0403-3.

4 S. Brookhart. *How to give effective feedback to your students.* Association for Supervision and Curriculum Development, Alexandria, Va, 2008.

5 J. Cravino. Planning teacher mediation in science and technology lessons. In J. B. Lopes, J. Cravino, E. de Souza Cruz, and A. Barbot, editors, *Teaching science: contributions of research for planning, practice and professional development*, University teaching and faculty development, pages 45–59. Nova Science Publishers, New York, 2017.

6 N. Faizan, M. Gottlieb, A. Loffler, M. Utesch, and H. Krcmar. State-of-the-Art to Measure the TPACK Level of Trainees in Higher Education to Increase the Learnability of the Train-The-Trainer (TTT) Sessions. In *2019 IEEE Global Engineering Education Conference (EDUCON)*, pages 384–391, Dubai, United Arab Emirates, April 2019. IEEE. doi:10.1109/EDUCON.2019.8725056.

7 OMG Object Management Group. Business Process Model and Notation (BPMN), Version 2.0. Technical Report formal/2011-01-03, OMG - Object Management Group, January 2011. URL: http://www.omg.org/spec/BPMN/2.0.

8 M. Kebritchi, A. Lipschuetz, and L. Santiague. Issues and Challenges for Teaching Successful Online Courses in Higher Education: A Literature Review. *Journal of Educational Technology Systems*, 46(1):4–29, September 2017. doi:10.1177/0047239516661713.

9 J. Kettunen. Strategy and Quality Maps in Higher Education. *US-China Education Review*, 8(2):149–159, 2011.

10 D. Pedrosa, J. Cravino, L. Morgado, C. Barreira, R. Nunes, P. Martins, and H. Paredes. Simprogramming : the development of an integrated teaching approach for computer programming in higher education. In *INTED2016 Proceedings - 10th International Technology, Education and Development Conference March 7th-9th, 2016 — Valencia, Spain*, pages 7162–7172, Valencia, Spain, March 2016. IATED Academy. doi:10.21125/inted.2016.0699.

11 A. Pereira, A. Quintas-Mendes, L. Morgado, L. Amante, and J. Bidarra. *Universidade Aberta's pedagogical model for distance education: a university for the future.* Universidade Aberta, Lisbon, Portugal, 2008. URL: http://hdl.handle.net/10400.2/2388.

12 M. Pereira. Model for production of teaching material: the use of bpmn notation in distance learning courses. *Review of Administration and Innovation - RAI*, 8(4):45–66, January 2012. doi:10.5773/rai.v8i4.898.

13 F. Siqueira, G. Barbarán, and J. Becerra. A Software Factory for Education in Software Engineering. In *2008 21st Conference on Software Engineering Education and Training*, pages 215–222, Charleston, SC, USA, April 2008. IEEE. doi:10.1109/CSEET.2008.10.

14 B. Trammell and C. LaForge. Common Challenges for Instructors in Large Online Courses: Strategies to Mitigate Student and Instructor Frustration. *Journal of Educators Online*, 14(1):10, 2017.