

Evaluating the Teaching of Project Management Tools through a Series of Case Studies

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Abstract: Project management (PM) tools are mandatory to properly manage software projects. The usage of these tools is an important competence for professionals in the computer area, and its teaching is addressed in superior computer courses. In this context, general usage tools are usually adopted, such as MS-Project, but the lack of educational features of in these tools has motivated the development of several educational PM tools. However, previous studies have shown that these tools still do not cover the whole PM process, as defined by PMBOK. As a result, this study aims at presenting an instructional unit to assist in the teaching of functionalities that support an extensive part of this process, covering the initiating and planning processes groups for all knowledge areas. It adopts an open-source and educational PM tool – dotProject+, and other instructional materials. The instructional unit was applied in several case studies in undergraduate computer courses. Its results demonstrated students were able to learn how to use the PM tool to carry out that part of PM process, and teachers state students learning was facilitated by the instructional materials adoption.

1 INTRODUCTION

Project Management (PM) is an important area for many organizations in the software industry. It is so because several projects still fail due to a lack of proper management, leading to problems related to unaccomplished deadlines, budget overrun, or scope coverage (The Standish Group, 2013). In this context, a project is defined as a temporary endeavor to achieve a single result, and PM is the use of knowledge, abilities, tools, and techniques that enable a project to reach its goals (PMI, 2013).

Project problems take place mainly because of the absence of a PM process (Keil et al., 2003), resulting in a narrow control over project restrictions (The Standish Group, 2013). The adoption of a PM process may be aided by the usage of a PM tool (Fabac et al., 2010). Despite many organizations still not using any PM tool, the positive contributions that these tools have brought about have increased the interest in their usage (Cicibas et al., 2010).

Given that the usage of PM tools is not well-established in organizations and that projects still fail, a possible cause for this may be the lack of teaching project managers and team members in the usage of

these tools (The Standish Group, 2013; Fabac et al., 2010; Reid and Wilson, 2007).

The teaching of PM has to address the knowledge on PM, beyond general knowledge on administration, project environment, and interpersonal abilities (PMI, 2013). However, the teaching of PM should not just be focused on theoretical knowledge, because this is not enough to employ the PM effectively. It is crucial to develop the project manager competencies, which include knowledge (theoretical), abilities (practical), and attitudes (Branch., 2009). In addition to this, the PM is infeasible without the support of a PM tool, due to the complexity of contemporary software projects. Furthermore, the usage of these tools is among the project manager competencies (PMI, 2013; Salas-Morera et al., 2013). A PM tool is a software that supports the whole PM process or just a specific part of it. Among its supported functionalities are: schedule development, cost planning, risk analysis, etc. (Car et al., 2007).

However, there are a wide variety of PM tools, and most of them are not suitable for teaching, complicating the learning of their usage (PMI, 2013; Keil et al., 2003). For instance, some PM tools demand an initial effort to setup the environment and to learn about its usage, thus being rejected by some students

during their first contact with them (Salas-Morera et al., 2013).

As an attempt to improve this scenario, some research (Reid and Wilson, 2007; Gregoriou et al., 2010) has identified that MS-Project is the most adopted PM tool for teaching. However, the lack of didactic features in this tool has motivated these research which proposes new educational PM tools (Salas-Morera et al., 2013). Most of these tools are focused on specific techniques, such as CPM, PERT, RACI Matrix. Nonetheless, when considering the PM process, none of these tools have focused on addressing of all PM knowledge areas. Thus, this paper presents an Instructional Unit (IU) that adopts the educational PM tool – dotProject+ – for teaching the usage of functionalities that supporting the execution of all PM knowledge areas for the initiating and planning processes groups.

An IU is a set of classes designed to teach certain learning objectives for a specific target audience. It consists of a set of instructional materials, for teachers and students, which are developed to enable the learning in a specific educational context (Hill et al., 2005).

The paper structure presents, in the background section, the main concepts related to software PM, PM tools, and teaching of PM tools. Section 3 presents related studies, and Section 4 presents the IU for teaching PM tools, including its instructional materials, such as the educational PM tool dotProject+. Section 5 presents the case study definition, which instances are presented in Section 6. In Section 7, we present the IU evaluation, along with a discussion of the research results, leading to the paper's conclusions in Section 8.

2 BACKGROUND

Concepts that are relevant to this research are presented in this section. All these concepts are utilized during the presentation of the IU and in the discussion of the case studies results.

2.1 Project Management

The PM directs the project activities and its resources in order to meet the project requirements. It is organized in 5 processes groups, which guide the PM process from its initiating to its closing (Figure 1).

Orthogonally to the processes groups, the PM processes are organized in 10 knowledge areas (Table 1), which may be addressed to effectively manage a project.

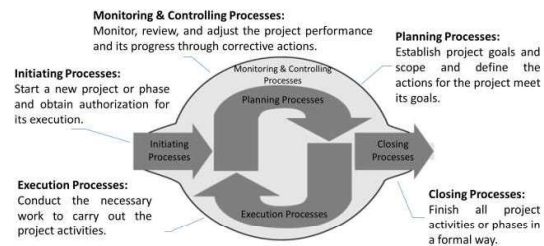


Figure 1: PM processes groups (PMI, 2013).

Table 1: PM knowledge areas (PMI, 2013).

Knowledge area	Processes to:
Integration	Identify and coordinate PM processes and PM activities.
Scope	Ensure that the project addresses the entire work to meet its requirements.
Time	Plan and control the activities that will be carried out during the project, so it concludes within the deadline.
Cost	Plan, estimate, and control project costs, so it concludes within the approved budget.
Quality	Define the goals, and quality policies, so the project meets the needs that have initiated it.
HR	Organize and manage the project team.
Communication	Ensure the generation, collection, and distribution of project information.
Risk	Identify and control the project risks.
Acquisition	Buy or contract products, services or any resources that are not available as project internal resources.
Stakeholder	Identify and manage the stakeholders and its expectations.

In the context of this study, the PM process refers to the one defined by PMBOK (PMI, 2013), which is the main reference in this area and is widely accepted worldwide (Ojeda and Reusch, 2013). The application of a PM process is aided by the usage of PM tools, which take advantage from technology either to support the whole PM process, or a specific part of it. This support may semi-automatize a few activities of the PM process, such as the schedule development, registering the project activities and its sequencing, and providing online forms to record their estimated durations and resources, then compiling its result in a gantt chart, instead of performing all the work manually (Cicibas et al., 2010). On the other hand, some PM process activities may be totally automated by PM tools, for instance, the calculi of project total cost, the critical path method identification, or its over allocated resources

(Fabac et al., 2010; Gregoriou et al., 2010).

2.2 PM Tools

Carrying out the PM process may be very complex, and demand many organizational resources. To assist its execution, many PM tools have been developed. Examples of PM tools are: MS-Project (microsoft.com/project), GanttProject (ganttproject.biz), DotProject (dotproject.net), Project.net (project.net), etc. (Fabac et al., 2010; Mishra, 2013).

However, due to the wide variety of PM tools, their functionalities and characteristics are very heterogenic (Pereira et al. 2013). The supported functionalities, for example, may cover the whole PM process, or just one or a few PM knowledge areas, or even more specifically just some activities, such as the tracking of worked hours or registering the project stakeholders.

Beyond its functionalities, other features may also influence the choice of the PM tool to be adopted for teaching. According to its features, some particularities of computational environment may be demanded, besides economic investments. Among these features, the most relevant are: availability, platform and usage propose.

The PM tools availability may be proprietary (the use of a license or acquisition is mandatory and it is maintained exclusively by a single organization) or open-source (free usage and maintained by users community). The proprietary PM tools may be adopted just by organizations that are prepared to perform its acquisition, while others may prefer to adopt an open-source tool, as a more economically savy alternative.

In terms of platform, there are the stand-alone tools (mono-user and desktop access) or web-based (multi-user and web browser access). In practice, a web-based PM tool has to be adopted to properly manage a software project, because it promotes collaborative work and information sharing (Cicibas et al., 2010). Thus, the teaching of these tools better prepares the student for a professional career (Reid and Wilson, 2007). However, the adoption of a PM web-based tool requires its installation in a web server that complies with the tool specification, and where internet access is provided to students.

Beyond the general usage PM tools, such as MS-Project or DotProject, that are focused on the professional daily routine, there are educational PM tools, which focus on student learning. These tools include didactic features, such as instructions about the usage of its functionalities, and simulations which

create scenarios that facilitate the usage of specific PM techniques. Some examples of educational PM tools are DrProject, ProMES and PpcProject (Gregoriou et al., 2010).

2.3 Teaching of PM Tools

The usage of PM tools figures among the project manager competencies (PMI, 2013). The need for teaching this competency is addressed by the ACM/IEEE reference curriculum for Computer Science (ACM and IEEE, 2013). It specifies that students have to develop knowledge in all PM knowledge areas, and have to learn the usage of a PM tool to develop a project schedule, to perform risk analysis, to monitor the project performance, etc. Often the teaching of PM tools includes the application of the following techniques (PMI, 2013; Reid and Wilson, 2007; Gregoriou et al., 2010): the Critical Path Method (CPM) – that identifies the project activities that cannot be delayed without affecting the project deadline; the Program Evaluation and Review Technique (PERT) – that calculates the estimated effort to carry out an activity based on three other estimates (worst case, most common case, and best case); the RACI Matrix - describes the participation by various roles in completing project activities; the Resources Levelling - technique in which start and finish dates are adjusted based on resource constraints, with the goal of balancing demand for resources with the available supply; amongst others.

3 RELATED STUDIES

Related studies have been identified by previous research (Gonçalves and Wangenheim, 2015) which has presented some IUs that adopts educational PM tools. Among all the studies that have been found, we have selected just the ones which present the IU evaluation through some case study with students in undergraduate computer courses.

3.1 DrProject

This related study (Reid and Wilson, 2007) presents an IU that make use of an educational PM tool, DrProject, that is open-source and web-based. This PM tool proposes to be simple enough to be learned in just a few hours, but covering several functionalities of PM tools. The employed strategy is focused on collaborative project development, involving students groups through PM tools

functionalities. This IU was applied during 4 semesters in Software Engineering disciplines. It begins with an expositive class, providing theoretical instructions about time, human resources, and communication management, and its support through PM tool functionalities. Afterwards, the class is organized into groups composed of 4 to 5 students, that have to develop a software project. The groups work on the project during the semester, and use DrProject to develop the project schedule, organize and share the project artifacts, and also to carry out the whole communication among group members. This IU was evaluated to identify whether the students considered it was simple to learn about the usage of a PM tool with the support of DrProject. The data collection occurred at the end of each semester, by students answering a questionnaire. Its analysis demonstrated that 2/3 of students considered PM tool usage simple to learn. Some general comments highlighted that students complained about the lack of a tutorial explaining DrProject functionalities. Another part of the evaluation was based on teacher observation, that highlighted the PM tool has motivated the students to produce the project artifacts with more quality, and has facilitated the collaborative work among the students.

3.2 ProMES

This related study (Gregoriou et al., 2010) presents an IU that uses the educational PM tool, ProMES, which is open-source and stand-alone, for teaching CPM, PERT and RACI matrix techniques. The instructional strategy is based on scenarios (problems) resolution. In each scenario the student has to solve a problem using a specific technique, and when it is solved, another one is presented with a higher level of difficulty. This tool includes some educational features, such as the configuration of student level of experience, namely: trainee and professional. At the trainee level the PM tool presents feedback, assisting the student to identify each error, conducting him to the scenario resolution. On the other hand, the professional level does not provide any assistance. Another instructional feature of this tool is the tutorial video that is presented when the student first accesses the tool, explaining how to use its functionalities. The usage of this tool had been evaluated by teacher observation, and also by collecting verbal feedback from students. It was applied with 121 students during 3 semesters. It leads to conclusions that the ProMES

promoted PM learning, highlighting the benefits of its educational features.

3.3 PpcProject

This related study (Salas-Morera et al., 2013) presents an IU that adopts the educational PM tool, PpcProject, which is open-source and stand-alone, and is focused on the teaching of CPM, PERT and resources allocation techniques. This tool has been developed to fulfil the same requirements provided by MS-Project when it is adopted for teaching, but to be superior for educational proposes. This IU was evaluated to verify whether students prefer to learn using PpcProject or MS-Project. It has been conducted through an experiment involving a total of 54 students. They were organized in two groups, control and experimental groups. Each group carried out the same activities, one using PpcProject, and other using MS-Project. In a second stage, each group carried out again the same activities, but using the other tool. Thus, each student has responded to 24 questions (12 for each PM tool). Their answers have been analysed by a non-parametric statistic test. This analysis has demonstrated that PpcProject is more suitable for teaching than MS-Project, except for the resources allocation process.

Analysing the IUs presented in the related studies, it is identified that the adopted educational PM tools have contributed for students learning. The assistance these tools provide have facilitated the content understanding, beyond facilitating the PM tool usage in class room. However, the IUs learning goals are generally focused on time and human resources management. Thus, considering the whole PM process, still there is a huge gap of what is currently been taught and all PM knowledge areas.

4 IU FOR TEACHING PM TOOLS TO SUPPORT THE PM PROCESS

In this context, this section presents an IU for teaching PM tools focused on initiating and planning processes groups, covering all knowledge areas. We have focused on these processes groups because they may be carried out within the IU discipline hours.

The execution of the planned projects may demand more hours than available, especially in the

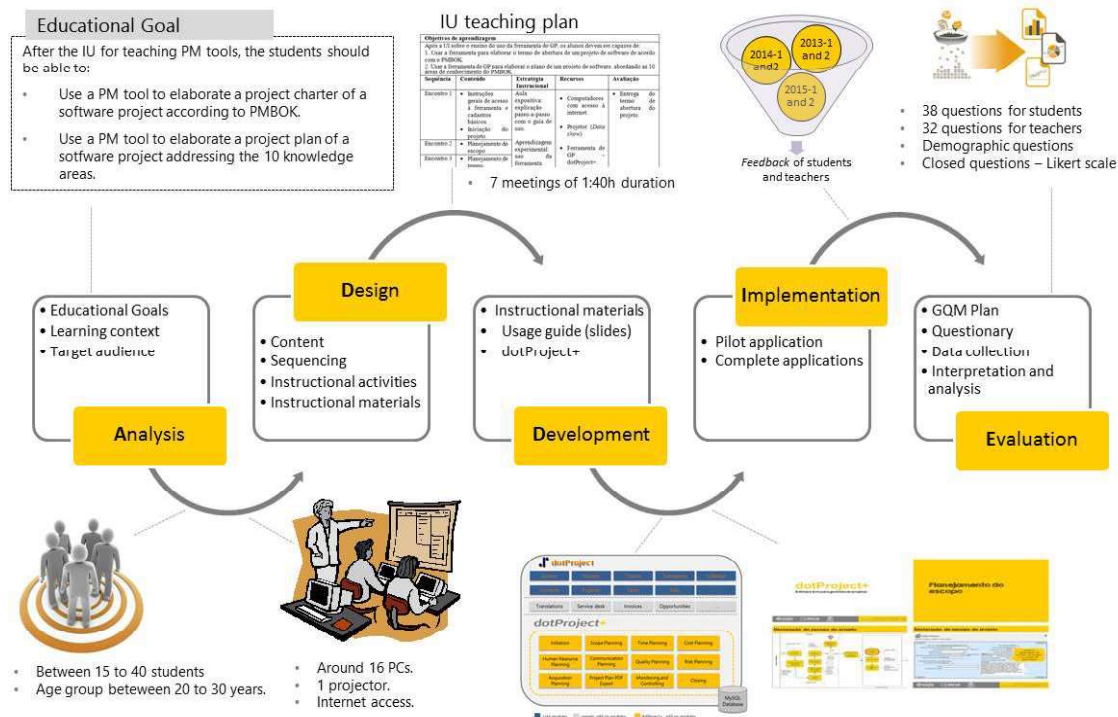


Figure 2: Execution of ADDIE process.

IU context, which projects are related to students term paper, demanding about a year to be concluded.

Effective and motivating IUs are developed following an Instructional Design process, for instance, ADDIE (Branch, 2009). An overview of the ADDIE process for the development of the proposed IU is presented in Figure 2.

As presented in Figure 2, the ADDIE process has 5 phases. Firstly, in analysis phase it is identified the target audience and the learning environment. This phase also includes the IU educational goals definition. Then, in analysis phase, it is defined the content to be addressed and its sequencing. This content is grouped in one or more meetings, and with the definition of instructional materials and activities, it composes the IU teaching plan. In the development phase, the instructional materials are developed, then leading to the implementation phase, which performs the IU application in class room. To evaluate the IU quality it is necessary to perform observations and data collection about teachers and students perception about the IU.

The next sections present details of instructional materials and about the IU evaluation process.

4.1 DotProject+

DotProject is one of most popular open-source tools for PM (Mishra, 2013). And previous studies have identified that among open-source alternatives, it is the most aligned with PMBOK (Pereira et al. 2013). DotProject architecture is organized in core modules, developed by its core team, and add-on modules, developed by users' community, which may be installed on demand. Thus, we decided to adopt this tool, not only because its wide coverage of the PM process, but also because its functionalities may be extended via add-on modules. In this context, dotProject+ was developed, being composed by dotProject core modules, and several add-on modules that have been developed to enhance dotProject functionalities to cover all PM knowledge areas and also include didactic features (Figure 3). An example of these features is the related to the organization of its functionalities, which are hierarchically grouped by processes groups, and then by knowledge areas. Thus, when the student is using a certain functionality, it is easy to identify what part of PM process are been supported by each functionality.



Figure 3: dotProject+ architecture.

Beyond adopting dotProject+, the IU also adopts the dotProject+ usage guide. This material is organized as presentation slides, which may serve to assist the teachers in expositive classes and students as a reference material. This material presents a process designed in BPMN notation (Weske, 2012), addressing all knowledge areas for the initiating and planning processes groups. Thus, this process defines the correct sequence to use dotProject+ functionalities, satisfying the requirements to execute each process activity before initiating it. Also, it presents print screens for each process activity, explaining how to use dotProject+ functionalities to support that part of the process (Figure 4).

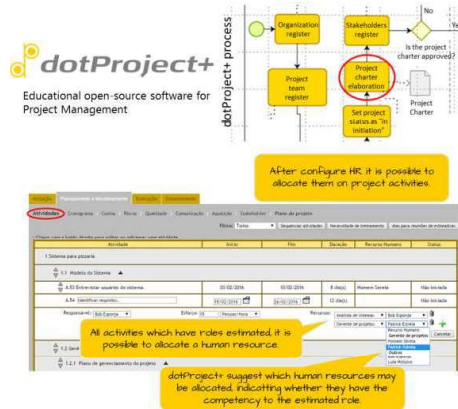


Figure 4: dotProject+ - Usage Guide.

All instructional materials are freely available and may be downloaded from dotProject+ web site (<http://www.gqs.ufsc.br/evolution-of-dotproject/>). Thus, any teacher interested may download all material and then apply the IU.

¹ This evaluation process has been approved by CEPISH/UFSC – an ethic committee for researches with human beings, and is registered under the number - 47734215.9.0000.0121.

4.2 IU Evaluation Process

The IU evaluation aims to identify its quality in relation to its content, instructional materials, user experience, students learning, and instructional strategy, based on students and teachers perspectives. It is carried out by a series of case studies, based on the empiric study process defined by Wohlin (2012) (Figure 5)¹. This evaluation process is integrated with the GQM approach (Basili et al., 1994), which is utilized to define the evaluation goal, the analysis questions which evaluate this goal, and metrics which support answering these questions.

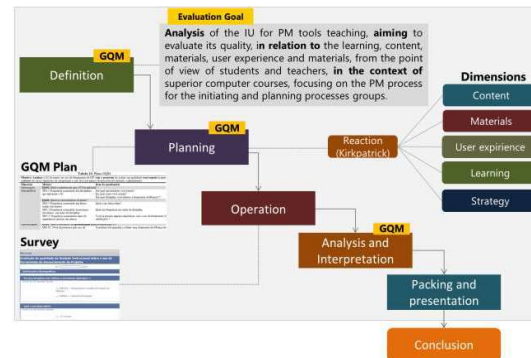


Figure 5: IU evaluation process (Wohlin et al., 2012; Basile et al., 1994).

Derived from the GQM metrics, data collection instruments were developed. There is a questionnaire for students and other for teachers, both containing the same structure: demographic questions followed by a set of affirmations using a likert scale to evaluate their perception of each IU dimension. These dimensions were chosen based on its compatibility with the proposed IU, and in accordance with previous studies (Arcuri and Fraser, 2012; Chen et al., 2013). At the end, there are open questions to collect points regarding strengths and improvements to be made, as well as other comments. The individual participation in the IU evaluation is voluntary and anonymous.

The perception about the IU quality is also evaluated by observation, analyzing the students and teachers behavior when interacting with the instructional materials, and when carrying out the instructional activities. In this case the data is collected by verbal or written feedback, that may be provided by e-mail or using an online form that was available for students and teachers along all the IU application.

5 CASE STUDY DEFINITION

Aiming to analyze the IU for teaching PM tools using dotProject+, a case study has been defined (Figure 6). The case study definition presents all steps necessary for this study to be reproduced in future situations (Wohlin et al., 2012).

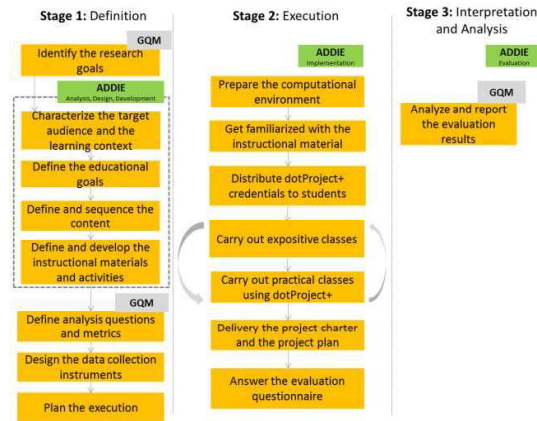


Figure 6: Case study definition (Wohlin et al., 2012; Basile et al., 1994).

The case study is organized in 3 stages. The first one is related to its definition, where the research goals are defined, and the IU is developed, addressing the analysis, design and development phase of ADDIE process. In this phase the IU evaluation is also defined, and the data collection instruments are developed. Details about the follow stages are presented in the next section.

6 CASE STUDIES EXECUTION

The case study has been reproduced during six consecutive semesters. It has been used in 3 different Brazilian educational institutions, applied by 6 different teachers, in a total of 13 classes, teaching more than 300 students (Table 2).

These case studies execution begins with teacher preparing the computational environment, installing dotProject+ and creating student accounts. The teacher also has to get familiarized with the instructional plan, with dotProject+ usage and with the usage guide.

At the beginning of classes, the students are organized in groups, receiving their credentials for

Table 2: Cases studies execution.

Semester	Educational institution	Course	Discipline	Teacher*	Number of students
2013-1	UFSC	Computer Science	Planning and management of software projects	Teacher A	19
2013-2	UFSC	Computer Science	Planning and management of software projects	Teacher A	21
2013-2	UFSC	Information Systems	Project management	Teacher B	23
2014-1	UFSC	Computer Science	Planning and management of software projects	Teacher A	30
2014-1	UFSC	Information Systems	Project management	Teacher B	22
2014-1	SEBRAE – Espírito Santo	Environmental Technician	Project management	Teacher C	19
2014-2	UFSC	Computer Science	Planning and management of software projects	Teacher A	17
2015-1	UFSC	Computer Science	Planning and management of software projects	Teacher A	24
2015-1	UFSC	Information Systems	Project management	Teacher D	19
2015-1	SENAC – Jaraguá do Sul	Information Technology Management	Fundamentals in Project Management	Teacher E	21
2015-2	SENAC – Jaraguá do Sul	Information Technology Management	Fundamentals in Project Management	Teacher E	24
2015-2	UFSC	Information Systems	Project management	Teacher D	37
2015-2	UFSC	Computer Science	Planning and management of software projects	Teacher E	28
Legend: UFSC – Federal University of Santa Catarina. SENAC – National Service of Commercial Learning. SEBRAE - Brazilian Service of Assistance of Small and Medium Enterprises. * Teacher names have been replaced for privacy reasons.					

dotProject+ access, and the teacher carries out expositive classes explaining how to access dotProject+, as well as general navigation rules. During the next meetings the teacher employs the usage guide to explain how to use dotProject+ to support the PM process for one or more knowledge areas, until the students complete the whole PM process for the initiating and planning processes groups. At the end of the classes, the students may export the project charter and the project plan in PDF format, and it is delivered to the teacher for evaluation.

After the IU application, the students and teachers are invited to answer an evaluation questionnaire. The answer of this questionnaire is non-mandatory, anonymous and online. Once the data are collected, it is analyzed and discussed, identifying the IU quality for each dimension, and its strengths and improvement points.

It is important to highlight that the case studies were not exactly reproduced, because the IU materials have been improved each semester, based on the feedback we have received, both by students and teachers. This feedback is normally related to improvement suggestions or from reporting some implementation issue. The feedback was provided verbally or in writing, using an online form or e-mail. In regards to data collection instruments, we have developed and applied the complete evaluation questionnaire (derived from GQM), but just in the case studies carried out after the second semester of 2014. In the previous semesters we applied a questionnaire with open questions for individuals to inform their improvement suggestions for the IU and its perceived strengths, as well as other general comments.

7 ANALYSIS

In this section we present the collected data from the students perspective, based on the received answers of the evaluation questionnaire. The analysis is segmented by each evaluation dimension, presenting the median of each questionnaire item, considering the 26 students that have answered it.

Firstly, concerning the **content dimension** (Figure 7), among the affirmations there are items about the content relevance for computer professionals, and whether it is addressed in proper depth and extension.

The **materials dimension** aims to evaluate the students perception about dotProject+ and its usage guide. The dotProject+ (Figure 8) was evaluated

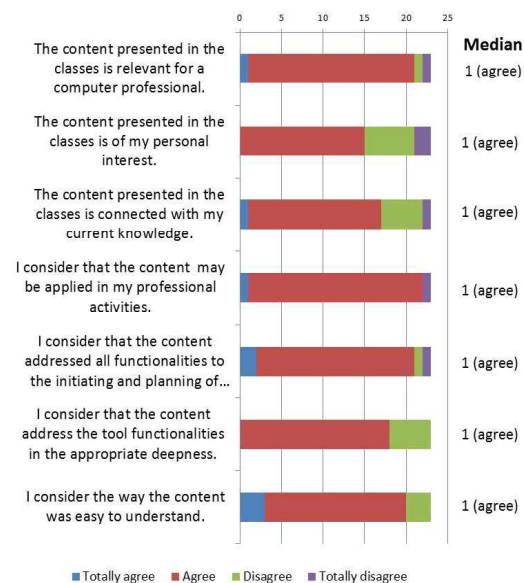


Figure 7: Content dimension evaluation data.

based on affirmations related to its contribution to the understanding about the practical application of the PM process, and also if it also assisted students during the instructional activities.

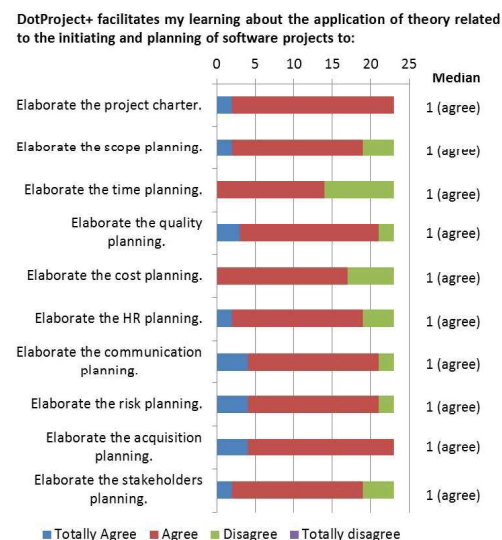


Figure 8: dotProject+ evaluation data for PM process coverage.

Yet, related to dotProject+, it was collected data about the students perception of its usability (Figure 9), and how much it stimulate students and the difficulties they may had faced during its usage.

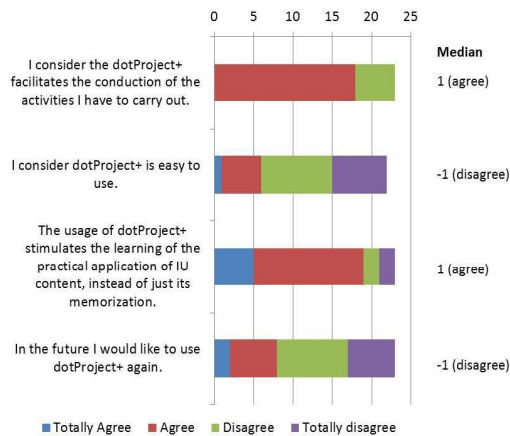


Figure 9: dotProject+ usability evaluation data.

Furthermore, we collected data to evaluate how the usage guide has contributed to students learning (Figure 10); identifying how it was consulted during the classes, and whether its content and structure are suitable for students learning.

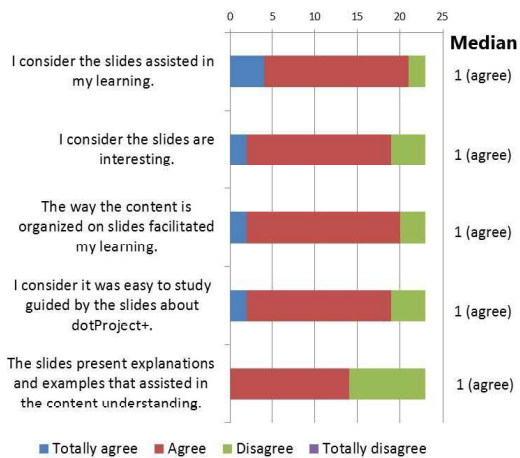


Figure 10: Usage guide slides evaluation data.

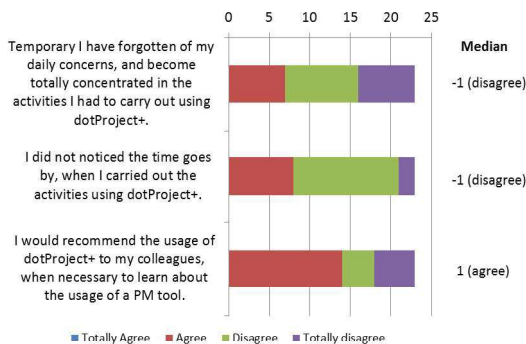


Figure 11: User experience dimension evaluation data.

The **user experience dimension** (Figure 11) was evaluated based on affirmations that attempted to identify how students become motivated when carrying out the instructional activities.

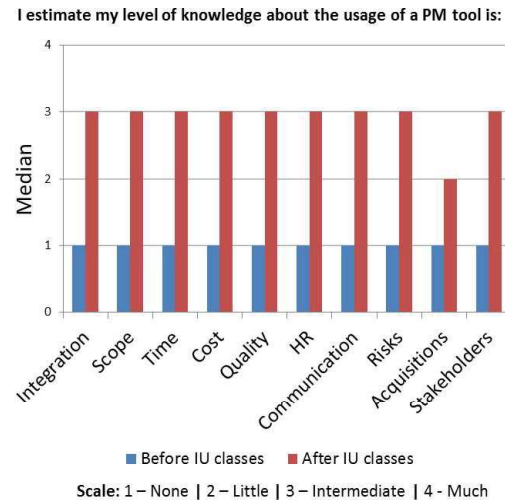


Figure 12: Learning dimension evaluation data.

Then, in relation to the **learning dimension** (Figure 12), we have utilized affirmations to understand the knowledge about PM tools usage in the beginning of the IU, and how it was after the IU.

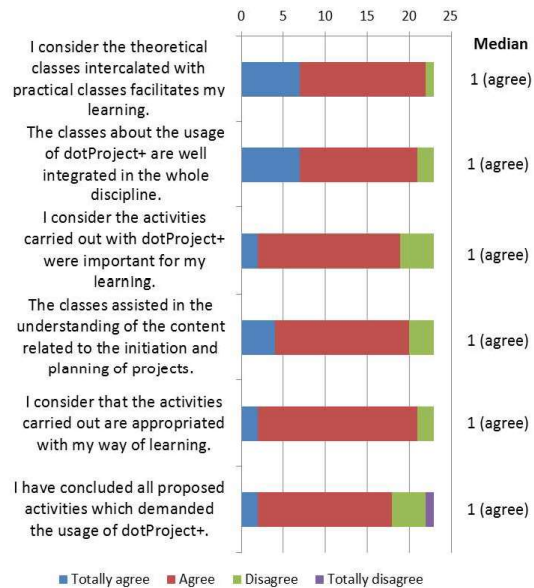


Figure 13: Instructional strategy dimension evaluation data.

The **instructional strategy dimension** (Figure 13) was evaluated based on affirmations about the contribution of theoretical classes and instructional

activities in students learning. In addition to its suitability to students learning preferences.

From the teachers' perspective, 5 of the 6 teachers have answered the IU evaluation questionnaire. Since we have more data about students evaluation than about teachers evaluation, we opted to present only the former. Nevertheless, in the discussion section we are addressing both perspectives.

8 DISCUSSION

In this section we present a discussion about the IU quality focusing on each dimension we have defined to be evaluated. We are considering the students and the teachers perspectives, collected both by the evaluation questionnaires and by observation.

Firstly, about the **learning dimension**, the students stated that the IU assists them to correlate the theoretical content with the professional practice, through the functionalities they learned to use on dotProject+. Also, the majority of students have finished all activities they were delegated, indicating they effectively have learned how to use a PM tool to elaborate a project charter and a project plan, covering all PM knowledge areas. From the teachers perspective they highlighted that the IU assisted the student learning, mainly because the employed instructional strategy and materials are strictly designed for the IU learning objectives.

Regarding the **instructional materials dimension**, the students stated that the usage guide assisted in their understanding about the whole PM process, explaining how to use dotProject+ functionalities to carry out each process activity. However, specifically about dotProject+, the most addressed issue was related to its usability, which in a few cases was considered complex to use. From the teachers perspective, they considered the entire instructional material, ready to use, assisted in classes preparation. They also considered the usage guide very important, especially because of the lack of experience of most students with PM tools. They also considered that the usage of dotProject+ assists in the learning of the whole discipline, because the students have the opportunity to apply the theoretical content through the tool functionalities. As regards to dotProject+ functionalities, they highlighted that it is very positive in supporting all of these processes in a single tool. It avoids the usage of several tools to cover all these functionalities, thus facilitating the integration of its results in a complete project plan generated by the tool. However, some teachers complained about the support provided by HR

allocation process, because it demands many steps, making it complex to be used. Other teachers also complained about the complexity for the installation of dotProject+, including many add-on modules, a complication when the teacher does not master the related technologies.

The issue about dotProject+ usability was drastically reduced after the 2015 first semester, when the dotProject+ version 2.0 was adopted, which had its usability improved based on an analysis carried out by a software usability researcher. In this same version we also have included a new theme, to make dotProject+ more attractive (in relation to the standard dotProject theme), also assisting in usability issues and facilitating student receptiveness. Regarding the issue related to the HR allocation process, it also has been improved in the dotProject+ version 2.0, which has simplified this process.

About the **content dimension**, the IU has received a positive feedback about the content coverage and depth, both by students and teachers. It was because dotProject+ supports several functionalities, enabling to apply on practice many PM techniques that are taught in theoretical classes, covering all PM knowledge areas. Most students also considered the content relevant for a computer professional.

In relation to the **user experience dimension**, the students highlighted that the most motivational aspect of the IU is that it enables them to have a clear comprehension about the practical application of the PM content. Although their motivation had been affected by the usability issues of dotProject+, this negativity has been reduced after the dotProject+ version 2.0 was adopted. From the teachers perspective they also considered that the IU prepares the students for their professional career, and all teachers have informed that they would recommend the IU to other teachers that need to teach about PM tools.

In relation to the **instructional strategy dimension**, the students considered that the intercalation between the theoretical and the practical classes has facilitated the content understanding, and also the comprehension of its practical applicability. Regarding the teachers perspective, they highlighted that the instructional activities guided by the PM process facilitated student understanding about the correct order to use dotProject+ functionalities. Thus, the result being, that most students concluded the elaboration of the project charter and the project plan.

Based on the presented discussion, it is evident that the proposed IU makes a positive contribution to student learning, and meets for teacher demands for all evaluated dimensions. During its application several improvement suggestions have been

collected, and many of them have already been implemented. Thus, at the current stage the IU reached a maturity level that allows it to be adopted by other teachers that need to teach about PM tools, aligned with the PM process as defined by PMBOK.

In comparison to related studies, thought the evaluation of the presented IU, it has demonstrated to assist in the teaching of a more extensive part of PM process than any other related studies. However, some studies, such as Gregoriou et al. (2010), besides covering just time and human resources knowledge areas for planning processes group, it offers several specific instructional features to assist students. Among these features are the configuration of difficulty level, automatic feedback, and tutorial videos. On the other hand, only the presented IU has adopted a material as the usage guide, which is oriented by the PM process, and provides instructions about how each step of this process may be supported by PM tools functionalities.

8.1 Threats to Validity

As any research there are some threats to validity (Wohlin et al., 2012). They are analyzed for conclusion, construction, and external threats to validity.

Threats to conclusion validity may occur due to inconsistencies in the data collected. In this research the individuals may lack some knowledge related to PM, even while being taught during the discipline. It may lead to wrong interpretation of questionnaire items and as a consequence lead to inconsistent answers. To reduce this threat, the questionnaire was designed carefully analyzing the employed terminology, bringing it as near as possible to the student language. Also, when the students answered the questionnaire still in the context of the discipline, they may have been afraid to be punished for their answers, especially when criticizing some IU aspects. This was mitigated by anonymising the answers, applying the questionnaire only after all student evaluations had been concluded and having this final process conducted by an external researcher, instead of the teacher. However, especially from a students perspective, a significant part of our evaluation has been based on data collected in an ad-hoc manner, based on verbal and written feedback provided during the case studies instances.

Threats to construction validity are related to the data collection instrument, which may not contain the necessary set of questions to reach the evaluation goal. We have employed the GQM approach to design the questionnaire, thus the evaluation goal was

systematically deployed in question analysis and metrics, which were represented by questionnaire items.

Threats to external validity may occur by not obtaining a significant sample. In fact, we still do have not collected a significant amount of structured data; consequentially performing the statistical study with only 26 students answers. However, we have mitigated that by applying the IU in different semesters, involving 6 teachers and 304 students, which are significant events for a general evaluation of the IU for teaching PM tools with the support of dotProject+.

9 CONCLUSIONS

This study has presented the evaluation of an IU for teaching the usage of PM tools. This IU has introduced the educational PM tool - dotProject+, which is an enhancement of one of the most popular open-source tools for PM. DotProject+ includes a more comprehensive support to the PM process and educational features. After carrying out a series of case studies, and analysing the collected data from students and teachers perspectives, the IU has demonstrated to be effective for teaching the usage of PM tools for the initiating and planning processes groups, covering all PM knowledge areas. Students highlighted that they have learned the content, and consider they are able to reproduce it in their professional activities. Teachers have highlighted they would like to use this IU again, and would recommend it to other teachers. Future studies may expand upon the instructional feedback of dotProject+, beyond the creation of other IUs to address other processes groups that were not included in this research.

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