Comparison of Educational Project Management Tools

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***Abstract*—Project management tools are mandatory to properly manage software projects. The teaching of the usage of these tools is carried out in higher education computer courses and, usually generic tools are adopted, such as MS-Project. However, their lack of educational features has motivated the development of several educational project management tools. This study aims at the analysis of such existing tools, carrying out a systematic comparison. Therefore, we selected the most relevant educational project management tools based on the results of a Systematic Literature Review. These results were updated, including newly available tools and excluding proprietary and no longer available ones. The selected tools are presented, highlighting their educational features, supported functionalities and content coverage considering the whole project management process. A systematic comparison is conducted, discussing each evaluation criteria, resulting in a guideline for choosing the proper educational project management tool according to the educational goal. The presented results may be useful for instructors of Project Management courses as well as for researchers, to guide further research based on the identified gaps in this area.**

Keywords-Project Management; Project Management Tool; PMBOK; Teaching; Education; Open-source.

I. INTRODUCTION

Project Management (PM) is a critical area for many organizations in the software industry. A significant amount of projects still fail due to a lack of proper management, causing problems related to unaccomplished deadlines, budget overrun, or scope coverage [1]. In this context a project is considered 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 [2].

Project problems occur mainly because of the absence of a PM process [3], resulting in a limited control over project restrictions and resources [1]. The adoption of a PM process may be facilitated by the usage of a PM tool [4]. A PM tool is a software that supports the PM process (either as a whole or partly), offering functionalities like: schedule development, resources allocation, cost planning, among others [7]. Despite the fact that many organizations still do not adopt any PM tool, the positive contributions that these tools may bring have increased the interest in their usage [5].

The responsibility for the usage of these tools lies with the project manager, who is accountable for the success of the project, having the authority to direct its resources in order to conduct the project by following a systematic PM process [2].

Given that the usage of PM tools is not yet common in organizations and that many projects still fail, a possible cause for this could be the lack of teaching the usage of these tools to project managers and team members [1][6][7].

The teaching of PM has to cover knowledge on PM, beyond general knowledge on administration, project environment, application area, and interpersonal abilities [2]. However, the teaching of PM should not just be focused on theoretical knowledge, as this is not enough for an effective PM application. And, as due to the complexity of contemporary software projects, PM is impracticable without the support of a PM tool, and the ability to use such tools is also among the project manager's competencies [4][8].

In Section 2, we present the background Section, followed by Section 3 that presents the analysis of related studies that have compared PM tools. In Section 4 we present the process we have adopted to carry out the educational PM tools comparison. In Section 5 we present each of the selected PM tools, and a structured comparison is presented in Section 6, leading to a discussion about each evaluated criteria in Section 7, resulting in a guideline for choosing the proper educational PM tool according to the educational goal. In Section 8 we present the conclusions of this study. These results may assist teachers in the teaching of this competence. They may also assist researchers in the improvement of support to the existing tools, or the development of new ones, covering the gaps that remain in this area.

II. BACKGROUND

Concepts that are relevant to this research are presented in this Section, namely: PM, PM tools, and teaching of PM tools. These concepts are used during the discussion of our findings, in terms of criteria for selection and evaluation of educational PM tools, or for analyzing their educational characteristics and general functionalities.

A. Project Management

PM conducts project activities and resources to meet its requirements, from its initiation to closure (Figure 1).

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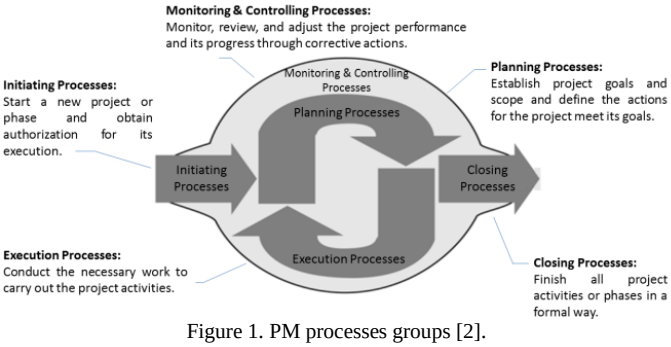

Figure 1. PM processes groups [2].

Orthogonally to these process groups, the PM processes are organized in 10 knowledge areas (TABLE I).

TABLE I. PM KNOWLEDGE AREAS [2].

Knowledge area	Processes to:
Integration	Identify, define, combine, unify, and coordinate PM processes and PM activities.
Scope	Ensure that the project addresses the entire work and meets all its requirements.
Time	Plan, monitor 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 responsibilities, goals, and quality policies so the project meets the needs that have initiated it.
Human Resources	Organize and manage the project team.
Communication	Ensure the generation, collection, distribution, storage, recovery, and final destination of project information.
Risk	Identify, monitor 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 [3], which is the main reference in this area and widely accepted [9].

The application of a PM process is assisted by the usage of PM tools, which support the PM process, either as a whole, or a particular part of it. This support may semi-automatize some activities of PM process, such as writing status reports or providing online forms to record meeting minutes [6]. Furthermore, some PM process activities may be totally automated by PM tools, such as for instance, calculating the total project cost, the identification of the critical path, or the identification of over-allocated resources [5][10].

B. PM Tools

Conducting the PM process may be very complex and demand considerable resources of an organization. To assist in its execution, many PM tools have been developed. Examples include: MS-Project, Primavera, DotProject, Project.net, etc. [4][11]. However, due to the wide variety of PM tools, their functionalities and characteristics are very heterogenic [5, 12]. Supported functionalities, for instance, may cover the whole PM process, or just one or a few PM knowledge areas, or, more specifically, just some activities, for example, the tracking of work hours [11, 12]. The scope of the offered functionalities influences the usage of these tools for teaching, as they may restrict the addressed content.

Beyond its functionalities, other characteristics may also influence the choice of a PM tool to be adopted for teaching. According to its characteristics, such a tool may require some particularities in the computational environment besides the need for economic investments. Among these characteristics are: availability, platform, and usage propose.

The availability of PM tools 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). Consequently, proprietary PM tools may be adopted only by organizations that are prepared to acquire its licence, while others may prefer to adopt as more low-budget alternative open-source tools.

In terms of platform, there are available stand-alone tools (mono-user and accessed via desktop) or web-based systems (multi-user and accessed via web browser). In practice, a web-based PM tool has to be used in order to properly manage a software project, as they allow collaborative work and sharing of information [4][5]. Thus, the teaching of these tools prepares the student better for a professional career [5]. However, the adoption of a PM web-based tool for educational proposes requires that this tool is installed on a web server that complies with the tool specification, and the students must have internet access.

Beyond the generic PM tools, such as MS-Project or DotProject that are focused on the professional daily routine, there also exist educational PM tools, which focus on student learning, such as ProMES and PpcProject [10]. These tools include didactic features, such as instructions about the usage of its functionalities, and simulations that create scenarios that propitiate the application of specific PM techniques.

C. Teaching of PM Tools

The usage of PM tools is part of the project manager responsibilities [2]. The need for teaching this competency is addressed by the ACM/IEEE reference curriculum for Computer Science [13]. 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, allocate resources, monitor the project, etc. Often the teaching of PM tools usage includes the application of the following techniques [2][7][10]: 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 Responsibility assignment matrix (RACI Matrix) – that describes the participation by various roles in completing project activities; Resources Leveling – technique in which start and finish dates are adjusted based on resource constraints,

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with the goal of balancing demand for resources with the available supply; amongst others.

III. RELATED STUDIES

Several studies have presented comparisons of PM tools using different criteria for tools selection and evaluation [5][11][14][15][16].

Mishra et al. [14] compared 20 popular PM tools, presenting a brief description of each one and comparing them, based on criteria like platform, availability, and functionalities (e.g., resources management, schedule development, and earned value analysis). However, no PM tools selection criteria were presented.

Dippelreiter et al. [15] presents the comparison of 4 popular open-source PM tools that are adopted in industry, but again do not present selection criteria. The evaluation criteria were based on a set of functional requirements obtained after conducting interviews with project managers. Among these functional requirements are: project maintenance, contacts, activities, costs, documents download/upload, etc.

Margea et al. [16] compares 9 PM tools, including proprietary and open-source, and also stand-alone and web-based PM tools. Selection criteria were not presented. This study presents a description of each tool, including its main features and functionalities. Then, these tools are compared based on their platform and supported functionalities (e.g., resource management, risk analysis, schedule development, etc.).

Cicibas et al. [5] presents a comparison of 10 PM tools, including proprietary and open-source tools, and stand-alone and web-based. They included tools that were subject of previous scientific studies, as well as to be popular in the PM community (based on forums, blogs, and non-official web sites).Besides these characteristics, the PM tools were compared based on their functionalities, including: schedule development, resource management, time tracking, change management, document management, risk assessment, collaboration, amongst others. These evaluation criteria are explained, describing the expected functionalities that characterize its attendance.

Pereira et al. [11] presents a comparison of open-source PM tools. These tools were selected based on a systematic search in Sourceforge, the most relevant repository of open-source tools, and the comparison criteria were based on a unified best practice of PMBOK [2] and CMMI-DEV [12]. This study has compared 5 PM tools, which are claimed to be the most relevant based on the defined criteria. For each PM tool the supported PM best practices are identified.

Analyzing these comparisons we may conclude that currently there exist a wide variety of PM tools, and although they share some common features, their functionalities vary significantly. Thus, the PM process is partially supported by most of these tools and the choice of a PM tool may differ according to organization demands. However, before choosing a PM tool, it is important to know how to use its functionalities to support the PM process, hence, performing a conscious choice. Aiming to assist in the teaching of PM tools functionalities, some educational PM tools were developed, but no comparison with this specific focus has been encountered. In this context, the contribution of the work presented here lies in the analysis and comparison of relevant open-source educational PM tools.

IV. TOOL ASSESSMENT

The goal of this work is to present relevant educational PM tools and to assess their characteristics, educational features and functionalities. To systematically carry out the tool assessment, we adopted the following research process:

(1) Selection of educational PM tools, based on previous researches that present these tools.

(2) Definition of evaluation criteria with respect to the PM tools characteristics, educational features, and general functionalities.

(3) Execution of the PM tools evaluation.

(4) Analysis and interpretation of the collected data.

This process has been conducted by a PhD student of the Graduate Program in Computer Science (PPGCC) of the Federal University of Santa Catarina/Brazil, and revised by a senior researcher with expertise in Software Process Improvement and Project Management.

A. Tools selection

Aiming at the selection of relevant educational PM tools, we based our selection on a previous research carried out by the authors, which performed a Systematic Literature Review on the teaching of the usage of PM tools [17]. Among the results of this study is the identification of educational PM tools adopted for teaching. In the current study we performed a deeper exploration of each PM tool, identifying when each of them may be adopted and creating a guideline to instructors, so they can choose which educational PM tool may be adopted according to their educational goals. Moreover, for this study we have updated the results found on [17], including new educational PM tools.

In this context, the inclusion criteria for tool selection are:

- PM tool must include educational features;
- PM tool must be open-source; and
- PM tool must be available for download.

The exclusion criteria are:

- The software must be a PM tool (not games, simulators or e-learning platforms); and
- The tool must be focused on “traditional” PM (e.g., excluding any tool focused exclusively on agile PM).

This search, conducted in June 2015, returned a total of 10 educational PM tools. Applying the defined inclusion and exclusion criteria, only 5 educational PM tools have been considered relevant in the context of our study. We excluded tools such as EduSet [18], CBT Module [19], and POM-QM [20], which appear to be no longer available. Other tools such as PSG [21] and PTB [22] were excluded because they are proprietary tools. These tools were excluded, as we aim at presenting only PM tools that currently may be adopted by instructors or researchers to assist in their activities. The selected educational PM tools are presented in TABLE II.

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TABLE II. SELECTED EDUCATIONAL PM TOOL.

PM Tool	Available for download at:
DrProject [23]	www.drproject.org
PpcProject [10]	http://code.google.com/p/ppcproject/
ProMES [24]	www.simor.mech.ntua.gr/Kirytopoulos/promes.asp
DotProject+ [25]	http://www.gqs.ufsc.br/evolution-of-dotproject
RESCON [26]	http://www.econ.kuleuven.be/rescon/

B. *Evaluation criteria*

Considering that only open-source educational PM tools are being evaluated, the evaluation criteria include the platform (stand-alone or web-based), educational features (aggregating all variations of educational features presented by the evaluated tools), PM techniques (that contains some educational support), and PM process coverage (in terms of knowledge areas and processes groups). These criteria are presented in TABLE III.

TABLE III. EVALUATION CRITERIA.

Description	Items to be evaluated
Platform	Stand-alone or web-based.
Educational PM features	• Scenarios to assist the application of specific PM techniques. • Feedback when students make some wrong usage of PM tool. • Hints to guide the student in the usage of PM tool. • Problems to be solved and definition of difficulty level. • Instructional materials to assist in the learning of PM tool usage. • Communication channels between students and teacher
PM techniques	CPM, PERT, Resources Leveling, RACI Matrix.
PM process coverage	
Knowledge areas	Integration, scope, time, cost, quality, communication, human resource, risk, acquisition, stakeholders.
Process Groups	Initiation, planning, execution, monitoring & controlling, closing.

For the evaluation of these criteria, only the functionalities that were presented by the authors of the PM tools were considered, excluding any undocumented functionality or extensions that may have been developed after their publication.

V. RESULTS EVALUATION

In this Section, we analyze each selected tool. The information presented for each tool include: its objective (for what it was designed), platform, a screenshot, main functionalities and educational features.

A. *DrProject*

DrProject (Figure 2) is a web-based PM tool, which was designed to assist students to understand the concept of a project and its lifecycle. It includes functionalities that assist the students to carry out an entire software project with team work, from its initiation to closure. Its main functionalities include features to assist team work, such as wiki, tickets, documents repository and mailing list. In addition, it also contains functionalities for definition of project activities and milestones.

Figure 2. DrProject.

The educational feature of this tool provides the instructor with a view of how students are performing at intermediate milestones. The forms were optimized to contain a minimum set of fields needed for didactic purposes, making it easier for students to understand the tool usage. The tool also provides administrative features that make it easier for the teacher to setup new projects and create new groups every term, thus reducing the time the instructor has to spend with administrative duties.

B. *PpcProject*

PpcProject (Figure 3) is a stand-alone tool that was developed to assist in the teaching of a PM tool with respect to CPM, PERT, and resources leveling techniques. This tool also has the goal to be at least comparable by students with other generic and proprietary tools, such as MS-Project.

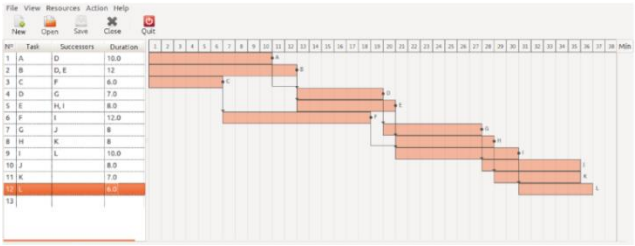

Figure 3. PpcProject.

The main functionality of this tool is focused on the schedule development, thus, supporting activity definition and sequencing, estimation of resources and durations, besides schedule development (Gantt chart).

The educational features are organized in three main modules: CPM, PERT, and Resource Allocation, which are the PM techniques this tool aims at teaching. The use of the CPM module is intended for students to deepen their understanding on the concepts of project activity decomposition, to analyze precedence relationships and to learn how to identify activities that cannot be delayed to achieve the expected completion date of the project, as well as to correctly interpret the Gantt chart. Using the PERT module students are expected to be able to calculate the project completion date in a probabilistic context and analyze the paths and critical activities during the project implementation. The Resources Allocation module includes features such as resources allocation, and identification of over allocated resources to apply resources leveling methods. By using this module, the students should be able to understand the influence of resource limitations on the project scheduling and propose alternative scheduling to improve resource usage.

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C. ProMES

ProMES (Figure 4) is a stand-alone tool that was developed exclusively for academic purposes and aims at students to understand how CPM, PERT, and RACI are used, besides enhancing conditions for the acquisition of the required knowledge based on pedagogical approaches.

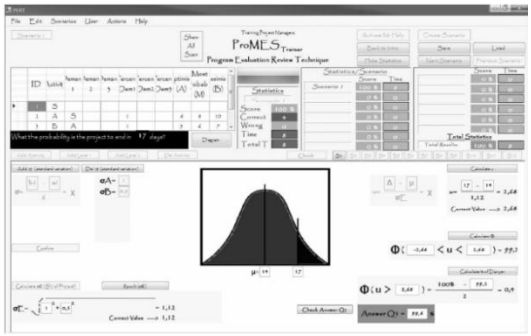

Figure 4. ProMES.

General functionalities include activity definition and sequencing, record estimations for effort, duration, and resources. The tool also supports the configuration of human resource roles and their allocation.

The educational features of ProMES, include CPM, PERT, and RACI matrix techniques. This tool offers the students feedback through interaction with the system. When the student begins to solve a scenario (exercise), the system checks and displays in message style all the errors. The student may revise his/her thoughts and try another solution. This procedure continues until no errors can be identified by the system. So, the student learns how to use the tool through feedback and tool interaction. Another very important educational aspect of ProMES is the help offered to the novice student. When the student first accesses the tool interface, a demonstration of how the tool works is displayed. In addition, the tool also gradually increases the difficulty of the proposed scenarios.

D. DotProject+

DotProject+ (Figure 5) has been developed to support the PM process to all knowledge areas for the initiation and planning processes groups. The educational goal of this tool is to assist the student to learn how to create a project charter and the project plan, supported by a PM tool. This tool is web-based and it is an enhancement of the generic PM tool – DotProject.

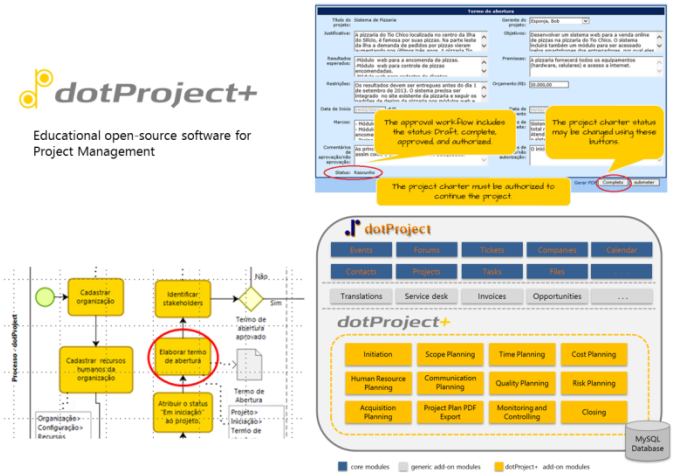

Figure 5. DotProject+.

Its functionalities include all standard functionalities of DotProject core modules, e.g., schedule development, calendar, contacts list, forum, tickets, etc. It also contains several add-on modules to include functionalities to cover all knowledge areas, for instance, registration of risk analysis, planned acquisitions, quality control plan, project stakeholders, etc.

Among the educational features, this tool includes instructional material, which explains the PM process and how it is supported by the tool's functionalities. Thus, it assists the student to conduct the PM process through learning the usage of a PM tool to support its execution.

E. RESCON: Educational Project Scheduling Software

The RESCON (Figure 6) is a stand-alone tool that focuses on the scheduling part of the PM process. It presents to students instances of the Resource-Constrained Project Scheduling Problem (RCPSP), that have to be solved with one of the many types of scheduling algorithms that are embedded in the educational PM tool.

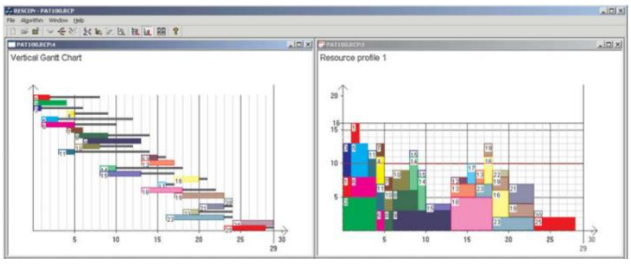

Figure 6. RESCON.

The general functionalities are related to the schedule development, and also with the human resource profiles configuration and allocation.

The educational features of this tool include the execution of CPM and the results of its execution are plotted with colored rectangles, which assist in the understanding of the related concepts, such as earliest and late possible start date, activity slacks and resources over allocation. The main educational feature of this tool lies in providing 48 kinds of

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algorithms to schedule development that may be executed and their results compared.

VI. COMPARISON

As part of the evaluation, we compare the support provided by the PM tools in relation to each evaluation criteria as presented in TABLE III. For the criteria related to PM tools platform, PM techniques and educational feature we used a nominal rating scale, indicating whether the PM tool contains or not a certain feature. For the criteria related to the PM process coverage we used a 4-point ordinal rating scale, rating the support level for each knowledge area or processes group as presented in TABLE IV.

The results of the comparison of the educational PM tools are presented in TABLE V, where each PM tool is evaluated over the defined criteria (TABLE III) using the evaluation scales (TABLE IV).

TABLE IV. SCALES FOR RATING THE EVALUATION CRITERIA.

Nominal rating scale	
-	The tool does not contain the feature.
X	The tool contains the feature.
4-Points ordinal rating scale	
-	The tool does not support the knowledge area or process group.
*	The tool supports minimally the knowledge area or process group.
**	The tool has a wide support for the knowledge area or process group, but it is not complete.
***	The tool offers complete support for the knowledge area or process group.

TABLE V. COMPARISON OF EDUCATIONAL PROJECT MANAGEMENT TOOLS.

Evaluation Criteria / **Educational PM Tools**	**DrProject**	**PpcProject**	**ProMES**	**DotProject+**	**RESCON**
Platform					
Stand-alone	-	X	X	-	X
Web-based	X	-	-	X	-
PM techniques (with educational support)					
CPM	-	X	X	-	X
PERT	-	X	X	-	-
Resource Leveling	-	X	-	-	-
RACI Matrix	-	-	X	-	-
Educational features					
Scenarios to assist the application of specific PM techniques.	-	X	X	-	X
Feedback when students make wrong usage of PM tool.	-	X	X	-	-
Hints to guide the student in the usage of PM tool.	-	X	X	X	-
Problems to be solved and definition of difficulty level.	-	X	X	-	-
Instructional materials to assist in the learning of PM tool usage.	-	-	-	X	-
Communication channels between students and teacher	X	-	-	-	-
PM process coverage					
Knowledge Areas					
Integration	*	-	-	***	-
Scope	*	-	-	***	-
Time	*	***	***	***	***
Cost	-	-	-	***	-
Quality	-	-	-	**	-
Communication	**	-	-	**	-
Human resource	*	**	**	***	**
Risk	-	-	-	***	-
Acquisition	-	-	-	**	-
Stakeholder	**	-	-	***	-
Processes Groups					
Initiation	*	-	-	***	-
Planning	**	**	**	***	**
Execution	*	-	-	**	-
Monitoring and Controlling	*	-	-	**	-
Closing	*	-	-	***	-

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VII. DISCUSSION

Analyzing the educational PM tools it is observed that only a few tools were developed with that propose, when compared with the wide variety of existing generic PM tools. Overall, we can observe that each tool is able to assist in the teaching for the purpose it was designed. However, considering the complete PM process, most tools have targeted only a specific part of this process and have included some educational feature to assist the students to understand this part and how it may be supported by PM tools functionalities.

Regarding the **educational features** presented by the analyzed tools, it was observed that these functionalities vary according to the educational goals. When the tool aims to teach the usage of a certain functionality, it presents instructions to demonstrate how to operate the software. Some tools present these instructions dynamically, depending on the student interaction with the tool. Some tools also present some usage guide to demonstrate how and when the PM tool functionalities may be utilized. When the goal is to teach the project life cycle, the PM tool typically includes functionalities for students to carry out a project from its initiation to closure, providing communication mechanisms between team members and the teacher.

With respect to the adopted **platform**, it was observed that the tools, which focused on the teaching of PM process are web-based. This is due to the fact that such a platform is more suitable to the process application in organizations, supporting multi-user accesses and information sharing among project stakeholders. These educational PM tools are closer to the real environment the students are going to face on real life projects. Considering the stand-alone PM tools, we can observe that they give support to just a few PM techniques. The adoption of this kind of platform may be justified when demanding a more complex user interface, using many charts and dynamic interactions, which may be easier to be developed on such platform.

The **PM techniques** that are usually taught through educational PM tools are CPM, PERT, RACI matrix, and resources leveling. The CPM technique is taught through different approaches. The ProMES tool requests the students to identify the critical activities analyzing the activity precedence diagram. The PpcProject tool requests the students to identify the critical activities by calculating its floats. The PERT method is taught in a similar way by most tools, requesting the student to enter her/his estimations for project execution and the three scenarios (best case, most common, and worst case), and then presenting the calculation for the PERT method. The RACI matrix is taught by ProMES only**,** allowing the students to assign responsibility, accountability, and consultancy, as well as to designate the representative who must be informed for each project activity. The Resources leveling technique is explicitly taught only by PpcProject, which imposes limits to the allocation of a certain resource, with the student having to find alternatives to develop the project schedule within the defined constraints. Both RACI matrix and resources leveling are also supported by DotProject+, but in this tool the student learns how to use it by instructions contained in the tool usage guide.

In this context, it becomes evident that the part of the **PM process** mostly addressed includes the knowledge areas time and HR, especially for the planning process group. An exception is the PM tool DotProject+, in which the PM process support stands out from the others, being is an enhancement of one of most popular open-source generic tools for PM. Hence, its functionalities are inherited, and gaps were filled by the addition of add-on modules. Some other tools also present specific exceptions, for instance, DrProject has a wide support for project communication, including support for document repository, wiki, and mailing lists, and also presents at least a minimum support to all processes groups.

Based on this analysis and comparison, we may identify when each of these PM tools may be more suitable for teaching. In situations when the educational goal is related to the teaching of specific PM techniques such as CPM, PpcProject, ProMES, or RESCON may be adopted. These tools provide scenarios that make it possible for the students to apply these techniques, and also evaluate the correctness of their answers, besides providing some feedback and explanations that make the teaching of these techniques easier. Specifically for teaching the PERT technique, both PpcProject and ProMES may be adopted. However, the resources allocation process is only partially supported by different tools. The PpcProject assists in the resource leveling technique, and ProMES assists in the creation of the RACI matrix. When intending to have support to all these techniques in a single tool, DotProject+ is an option. However, the instructor has to adopt some instructional method to teach these techniques, as even though DotProject+ supports all these functionalities, it does not contain many dedicated educational features to assist the students.

Nevertheless, when the educational goal is to teach about the PM process, DrProject and DotProject+ should be adopted. DotProject+ gives a wider support to the PM process than DrProject, providing the students with the opportunity to learn how to use several functionalities dedicated to all knowledge areas, such as risks, acquisition, quality and others, which are not covered completely by DrProject. Thus, it is important to understand that each educational PM tool has its own purpose. But the complexity of the usage of a PM tool is still not completely covered by any of the analyzed tools. So, it is important to know which tool may be suitable for each situation, according to the educational goals.

A. Threats to Validity

Several potential threats may have reduced the validity of the results of our work. The first threat we have identified is the existence of educational PM tools, which were not found by this research. This may occur when some PM tool was developed, but not published. However, we minimized this risk by basing our search on earlier and related work and performing an broad search on this topic.

Another threat to this research is the personal opinion of the authors by extracting the evaluated characteristics. To minimize this risk we considered only functionalities and

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educational features that were documented. Thus, it is possible that some PM tool contains some additional feature or functionality that is not documented, which thus was not included in our analysis.

Our specific focus on open-source educational PM tools may also represent a threat. As a consequence we excluded 2 proprietary tools, PSG and PTB, which claim to have many interesting educational features, such as simulations, that propitiate the student to have ideal scenarios to learn about project monitoring and controlling. However, these tools are not fully available to be adopted by instructors or researches without additional expenses.

VIII. CONCLUSIONS

This research aims at the comparison of educational PM tools that are openly available, identifying their characteristics, educational features, and supported functionalities. To reach this goal, educational PM tools were selected based on results derived from a Systematic Literature Review. Each selected PM tool was analyzed. The analysis describes each evaluated tool and presents a discussion of when each of these tools is more suitable to be adopted for teaching.

Hence, despite the efforts, it is evidenced that there is no tool that is complete enough to attend all educational demands, and it still is necessary to adopt a set of tools, according to the part of the PM process it aims at teaching. Future work may suggest enhancements on some educational PM tool to include support to all knowledge areas and process groups, expanding the educational features and then covering the gaps still existing in the teaching of the usage of PM tools.

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