



CENTERIS – International Conference on ENTERprise Information Systems / ProjMAN – International Conference on Project MANagement / HCist – International Conference on Health and Social Care Information Systems and Technologies 2022

Quality management practices to direct and control the accomplishment of project objectives in R&D units

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Abstract

Projects create value and capabilities for organizations and beneficiaries of their outcomes and must be managed by implementing quality processes to assure an execution compliant with plans, activities, and applicable standards, and to accomplish the defined requirements and objectives in an efficient and effective manner. This study analyzed the frequency of use of quality management practices by companies with R&D units and compared them with project management students' expectations of implementing quality project management practices as a professional. The data was collected using an online survey, and twenty-six quality management practices have been analyzed using descriptive and inferential statistics, following standard procedures, and using the Independent-samples T-test. For twelve out of the twenty-six practices, significant differences have been found between the two samples, five referring to quality planning practices and seven referring to quality control practices. For the twelve quality management practices, project management students had greater expectations of implementing them, in contrast to the actual frequency of use among the surveyed companies. The results can provide inputs to improve project management practices among companies, reinforcing the importance of training and recruiting project management professionals that have the required training, talent, and aligned expectations on how to successfully manage projects.

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Peer-review under responsibility of the scientific committee of the CENTERIS – International Conference on ENTERprise Information Systems / ProjMAN - International Conference on Project MANagement / HCist - International Conference on Health and Social Care Information Systems and Technologies 2022

Keywords: Project management; Quality management; Quality processes; Quality practices.

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1. Introduction

Project management, according to ISO 21502, can be seen as a set of “coordinated activities to direct and control the accomplishment of agreed objectives” [1]. A project is a focused endeavor to retain or to add value or capability for the sponsor organization and the internal and external stakeholders. To accomplish the project objectives, management procedures and practices must be implemented, which allow initiating, planning, monitoring, controlling, and closing of the project, while managing resources, directing and motivating people, and setting processes and methods designed in a holistic and systemic perspective that must include the necessary practices to reach the defined objectives [1], [2], [3], [4].

Quality, according to ISO 9000, corresponds to the “degree to which a set of inherent characteristics of an object fulfills requirements” [5], and the quality management purpose, according to ISO 21502, is to “increase the likelihood that outputs are fit for purpose or use. Quality should be an integrated part of the project’s plan. Quality management includes identifying quality requirements with acceptance criteria and means of verification and validation, the standards to be used, and the deliverables of the project, including internal, external, interim, final, tangible, and intangible deliverables” [1].

Managing project quality includes developing a quality management plan and establishing quality policies, processes, and objectives that can be achieved through quality planning, quality control, quality assurance, and quality improvement [5].

Quality planning is focused on setting objectives and specifying operational processes and resources to achieve the project objectives, quality control is focused on complying and fully achieving the defined project requirements, quality assurance is focused on verifying compliance with defined plans, procedures and standards, and quality improvement is focused on the effectiveness, efficiency, and traceability of all project activities [5].

In this study, we compare the frequency of use of quality management practices, within the scope of R&D projects in industrial companies, with project management students’ expectations of implementing quality project management practices as a professional. Paying attention to these and other project management practices can provide inputs to improve project management practices among companies, reinforcing the importance of training and recruiting project management professionals, that have the training, the talent, and expectations on how to successfully manage projects.

Data has been collected using an online survey about project management practices and the data has been processed using descriptive and inferential statistics, following standard procedures, and using the Independent-samples T-test, 2-tailed p -value $<0,05$ applying the Levene’s test for equality of variance to assure the compliance with the homogeneity of variance assumption, to find significant differences between the frequency of quality project management practices used by companies and the students’ expectations of implementing quality project management practices as a professional. A confidence interval of 95% was used and the data were processed using IBM SPSS Statistics.

The article is structured in five sections. The 1st section is “introduction”, where the study is presented and the objectives are defined, the 2nd section is dedicated to “Quality processes” providing the basis of fundamental concepts of quality management processes, the 3rd section, “Methodology”, describes the study approach, the 4th section “Results” presents the study findings, and the 5th section presents the conclusions.

2. Quality processes

Quality means ensuring that we achieve what we said we would, and that we do it as efficiently as we can [6]. To ensure that we effectively achieve what we set out to do, the project manager must ensure that the project starts with a correct and complete definition of requirements.

Quality is defined as a function of the project requirements, if the requirements are not well defined, it will be difficult to measure the scope of what we set out to accomplish against what was achieved [7].

According to Greene & Stellman, “When the requirements of a product are unclear, that product may pass all quality tests and even then, it may not be able to satisfy the needs and/or expectations of the customer or end consumer. Therefore, having correct and well-defined requirements is the only way to determine if the product presents high quality and value to project stakeholders” [6].

To ensure quality, a project must be structured considering three quality management processes that focus on meeting the stakeholders' requirements and expectations to deliver the defined outcomes, and those quality processes are [1], [2], [3]: Quality planning, Quality control, and Quality assurance.

2.1. *Quality planning*

According to ISO 21500, the purpose of quality planning “is to determine the quality requirements and standards applicable to the project and project deliverables and how the requirements and standards will be met, under the project objectives” [2].

When planning quality, it is necessary to gather all the information available at the beginning of the project to determine what should be monitored and measured throughout the project to assure compliance with requirements and prevent deviations and defects that may occur [6]. In this process, we must consider the cost of quality, considering a cost-benefit analysis - how much will the planning and quality management activities cost versus how much we will earn by carrying them out [8].

Planning quality should include determining and agreeing on the objectives to be achieved and quality standards to be met, defining quality metrics and acceptance criteria for the project deliverables, establishing procedures, methods, techniques, tools, and resources to implement the planned quality actions to meet objectives and applicable standards, and assigning responsibilities and monitoring plans [1].

When planning for quality, the frequency, type, time, and place where monitoring and measurement activities must be carried out must be defined, and the project organization must define the applicable monitoring and measurement methods, including statistical techniques, and the extent of its use, and should assess its effectiveness [9]. The collected data must be analyzed to review the performance and success of a project.

The main benefits associated with quality planning are associated with [6]: (1) better description and characterization of project requirements; (2) reduction of correction/rework activities; (3) improvement of efficiency and productivity; (4) improvement in the satisfaction of the project team (greater probability of achieving the intended results); (5) improvement of customer satisfaction; (6) improvement of competitiveness factors of the project team and the company.

It is expected that due to better quality planning project deliverables will be better, and the costs of non-quality will be lower [8].

2.2. *Quality control*

According to ISO 21500 the purpose of quality control “is to determine whether the objectives established for the project, the quality requirements, and the standards are being met and to identify the causes of non-compliance and the ways to eliminate unsatisfactory performances” [2].

Quality control should include verifying that the project outputs and deliverables meet the quality requirements using the defined procedures, techniques, and tools to detect any deviation or defect from the established measurement targets and tolerances, analyzing the causes of poor quality and performances to course-correct and to devise preventive and corrective action plans [1].

Controlling quality corresponds to the actions developed during the project to ensure that the activities of quality planning are being carried out and achieved [10].

Quality control actions include: (1) Carrying out actions to monitor and measure the quality requirements and assumptions defined for the project. (2) Validation and verification of the degree of achievement of project requirements and objectives. “Each and every project deliverable needs to be inspected to ensure it meets quality standards. If we find defects, the team must correct them, and afterward, the repairs must be verified to ensure that the defects have been corrected” [6]. (3) Preparation of adjustment and project recovery plans to manage deviations, problems, and/or quality opportunities. (4) Making change requests. (5) Updating documents and project management plans according to updates and change requests. (6) Identification and dissemination of lessons learned [10].

Among the quality control activities, we also have the inspection and testing of project deliverables.

When we run a test, we must know exactly what is expected from the product, according to Greene & Stellman, “Testing involves checking to ensure that the product does what it is supposed to do, this means we must have a very

clear idea of what it is what is expected of the product so that we can assess its quality. That is why one of the most important concepts for quality is compliance with requirements.” [6].

Quality control must be applied throughout the life cycle of the project and includes, according to ISO 21500: (1) Monitoring whether the quality of deliverables and processes is being met and detecting defects using established tools, procedures, and techniques. (2) Analysing the possible causes of defects. (3) Determining preventive actions and change requests. (4) Communicating corrective actions and change requests to appropriate members of the project organization [2].

Quality control makes use of a multitude of quality tools, including statistical process control tools, such as control charts, capability analysis, parametric and non-parametric statistical tests, regressions, time series analysis, etc.

Quality control is also an inseparable part of project monitoring and performance assessment. Progress assessments should be used to (1) Assess whether the project tasks are well synchronized and interconnected. (2) Evaluate the allocation of human and material resources. (3) Check whether there are over-allocated resources. (4) Identify and evaluate activities and results that may negatively or positively affect the achievement of project deliverables. (5) Obtain inputs for the project remaining work. (6) Facilitate communication. (7) Evaluate compliance with the project time and cost baselines and other specified plans. (8) Lead improvements by identifying deviations and risks. (9) Facilitate the development of project recovery plans [11], [9].

The outputs of the progress assessment must be compared with the planned actions and objectives to determine if the project performance is acceptable and to define actions and recovery plans.

Throughout the project changes must be registered and controlled, according to ISO 21500, project managers must register change requests, and evaluate them in terms of benefit, scope, resources, time, cost, quality, and risk, assessing their impact before implementation [2]. A change request may be modified or even canceled depending on the assessment of its impact. Once the change is approved, the decision must be communicated to all relevant stakeholders for its implementation, including updating the project documentation as appropriate.

2.3. Quality assurance

According to ISO 21500, the quality assurance purpose is to assure the project execution compliance to project plans including all processes, tools, procedures, techniques, and resources necessary to achieve the project deliverables and baseline requirements [2].

The purpose of quality assurance, according to Greene & Stellman, is to improve processes to assure that the work is carried out effectively and efficiently, seeking to reduce waste and eliminate activities that do not add value, and is carried out with the fewest possible defects and under the specified requirements [6].

Quality assurance should include reviewing the project objectives and applicable standards to verify that they are being used, verifying conformity to the defined quality procedures, plans, methods, techniques, tools, and resources, and verifying results against the defined requirements and specifications [1].

Quality assurance activities consider information from quality planning and quality control to improve methods and processes with an impact on the execution of project deliverables.

Quality audits are used to verify conformity to applicable requirements, quality processes, and standards, according to Miguel, Saraiva, *et al.*, and Pinto, quality audits are meant to assess whether the project complies with the processes, requirements, and quality policy of the company or client and is an instrument to support and improve the effectiveness and efficiency of project tasks [8], [9], [12]. The analysis and understanding of the company's processes favor information flows and work efficiency, avoiding planning redundancies and following the company's or client's quality guidelines. Project-level quality audits also aim to assess the relationship between what was planned and what is being performed to assure the quality of project deliverables, according to PMBOK, the “quality assurance process favors continuous improvement. Continuous improvement is an interactive means to improve the quality of all processes. Continuous process improvement reduces waste and eliminates activities that do not add value. This allows processes to operate with greater levels of efficiency and effectiveness.” [3].

3. Methodology

To compare the frequency of use of quality management practices, within the scope of R&D projects in industrial companies, with project management students' expectations of implementing quality project management practices as a professional, an online semi-structured survey has been created to support data collection.

The survey included 26 questions, referring to quality management practices, which aimed to characterize the frequency of use of each practice. A Likert scale was used where 0 corresponded to “was never used” and 5 to “always used”.

The survey was answered by 34 out of 1511 companies that have R&D units according to the Portuguese scientific and technological potential survey (IPCTN, 2017[†]), and only non-certified companies under the Portuguese standard NP4457 [13] that defines the requirements of an R&D and Innovation system have been considered. This decision was taken because certified companies under NP4457 must comply with requirements leading to a more structured project management approach, and they are a smaller fraction of companies with R&D units (there were 164 certified companies under the standard NP4457 (IPAC, 2017[‡]). The survey was also answered by 36 project management students from the Alumni Association of the University of Minho (AAEUM) to get to know their expectations of applying quality project management practices as a professional.

Data analysis involved descriptive and inferential statistics, following standard procedures, and using the Independent-samples T-test, 2-tailed p -value $<0,05$ applying the Levene's test for equality of variance to assure the compliance with the homogeneity of variance assumption, i.e., if there were evidence of significant differences between the frequency of quality project management practices used by companies and the students' expectations of implementing quality project management practices as a professional. For the analysis, a confidence interval of 95% was used. Data were processed using IBM SPSS Statistics.

4. Results

4.1. Quality Planning

Data has been collected regarding the following quality planning practices:

- a) Save the project baseline (scope, time, and costs) to control the project progress and deviations.
- b) Define quality metrics for the verification and validation of expected results*.
- c) Create inspection and test plans to verify and validate project deliverables.
- d) Define quality checkpoints to verify and validate requirements achievement*.
- e) Define quality tools to monitor and measure project deliverables*.
- f) Identify and analyze quality standards applicable to project deliverables*.
- g) Create work instructions for project tasks.
- h) Create operational instructions for machines and equipment.
- i) Define an internal audit plan to assure the project quality*.
- j) Create control plans to verify the compliance of supplied critical project resources.

For five of the above-stated quality planning practices, identified with an asterisk (*), evidence has been found to assume that there are significant differences between the samples, using the independent samples T-test, 2-tailed p -value $<0,05$ applying the Levene's test for equality of variance to assure the compliance with the homogeneity of variance assumption, i.e., there is evidence of significant differences between the frequency of project management practices being used by companies and the students' expectations of implementing quality project management practices as a professional. For all these quality planning practices, project management students have greater expectations of implementing them, in contrast to the actual frequency of use among the surveyed companies.

[†] IPCTN - Portuguese scientific and technological potential survey. DGEEC – General direction of statistics in education and science. <http://www.dgeec.mec.pt/np4/44/?page=0>, June, 2022.

[‡] IPAC - Portuguese institute of accreditation. <http://www.ipac.pt/>, June, 2022.

4.2. Quality control

Data has been collected regarding the following quality control practices:

- a) Periodically monitoring the achievement of project objectives.
- b) Carry out the planned actions to monitor and measure the achievement of project requirements.
- c) Keep records of quality control tests.
- d) Identify improvement actions throughout the project life cycle*.
- e) Identify areas for improvement and good practices throughout the project life cycle*.
- f) Prepare project progress reports*.
- g) Determine the causes of deviation between the project baseline and the actual execution throughout the project life cycle*.
- h) Analyze the impact of deviations between the project baseline and the actual execution throughout the project life cycle*.
- i) Keeping records of quality defects throughout the project life cycle*.
- j) Develop a project recovery plan (if necessary) *.
- k) Keeping records of problems with procurement processes throughout the project life cycle.
- l) Keeping records of relevant project decisions.
- m) Keeping records of relevant project occurrences (non-compliance events, risks, conflicts, or new entries or relevant events for the project).
- n) Keeping records of change requests.
- o) Keeping records of changes to project plans.

For seven of the above-stated quality control practices, identified with an asterisk (*), evidence has been found to assume that there are significant differences between the two samples, using the independent samples T-test, 2-tailed $p\text{-value} < 0,05$ applying the Levene's test for equality of variance to assure the compliance with the homogeneity of variance assumption, i.e., there is evidence of significant differences between the frequency of project management practices being used by companies and the students' expectations of implementing quality project management practices as a professional. For all these quality control practices, project management students have greater expectations of implementing them, in contrast to the actual frequency of use among the surveyed companies.

4.3. Quality assurance

Data has been collected to assess if there were significant differences regarding the use of quality audits to assess the project performance and compliance with the project baseline, applicable normative standards, and legislation.

Using the independent samples T-test, 2-tailed $p\text{-value} < 0,05$ applying Levene's test for equality of variance to assure compliance with the homogeneity of variance assumption, no evidence has been found of significant differences between the frequency of quality project management practices being used by companies and the students' expectations of implementing project management practices as a professional

5. Conclusion

Project success is based on fundamental aspects of culture, talent, and processes to meet their goals [14]. Quality management processes ensure that activities necessary to design, plan and implement a project are effective and efficient assuring its performance and accomplishment of the project goals.

Project quality management is a continuous process and is more about assuring compliance with process, product/service requirements, and applicable policies, standards, and legislation than it is about figuring out defects and fixing poor quality outputs. It is also a continuous cycle of measuring and updating processes to achieve the desired quality focusing on the stakeholder's satisfaction [15].

To assure processes quality, project managers must think strategically about the overall development process from early R&D to commercialization considering cost expenses and savings, benefits, and market potential throughout a project, or multiple projects, to support decision making [16], and they must implement project practices, principles and methodologies to implement an appropriate management plan [14].

Organizations should be able to use several available project management methodologies and observe principles to adjust them to the specific constraints and requirements of the project to be developed [17].

Project management references such as PMBOK [3], SCRUM [18], Prince 2 [19], RUP - Rational Unified Process [20], Kanban [21], eXtreme Programming – XP [22], Dynamic systems development method – DSDM [23], Feature Driven Development – FDD [24], among other project management references, can be used to guide project deployment. Standards, such as the ISO 21500 [2] and ISO 21502 [1], describe concepts and processes to guide good project management practices, and the Portuguese standards NP 4458 [25] establishes the requirements to manage R&D and Innovation projects, and NP 4457 [13] that defines the requirements of an R&D and Innovation system, can also be used to guide project management practices [26].

This study aimed to compare the frequency of use of quality management practices, within the scope of R&D projects in industrial companies, with project management students' expectations of implementing quality project management practices as a professional. Data was collected regarding 26 project quality management practices, and we have concluded that for 12 of them, there are significant differences between the frequency of project management practices used by companies and the students' expectations of implementing them as a professional, namely:

- a) Five quality planning practices: 1) Defining quality metrics to verify and validate results; 2) Defining quality checkpoints to verify and validate requirements achievement; 3) Defining quality tools to monitor and measure project deliverables; 4) Identifying and analyzing quality standards applicable to project deliverables; 5) Defining an internal audit plan to assure the project quality.
- b) Seven quality control practices: 1) Identifying improvement actions throughout the project life cycle; 2) Identification of improvement areas and good practices throughout the project life cycle; 3) Preparing project progress reports; 4) Determining the causes of deviation between the project baseline and the actual execution; 5) Analyzing the impact of deviations between the project baseline and the actual execution; 6) Keeping records of quality defects; 7) Developing a project recovery plan (if necessary).

For the 12 quality management practices, project management students have greater expectations of implementing them, in contrast to the actual frequency of use among the surveyed companies.

Regarding quality assurance, no significant differences were found considering the frequency of quality audits to assess the project performance and compliance with its baseline, applicable normative standards, and legislation.

Paying attention to these and other project management practices and the significant differences found between the two samples can provide inputs to improve project management practices among companies, reinforcing the importance of training and recruiting project management professionals, that have the training, the talent, and expectations on how to successfully manage projects, designing, planning and implementing effective and efficient quality management practices to accomplish the project goals.

In future work, a broader approach to project management can be carried out considering the PMBOK [3], five phases of project management 1) initiation, 2) planning, 3) Execution, 4) monitoring and control, and 5) closure, to have an integrated perspective of project management practices, figuring out, the significant differences between the samples.

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