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Professors' Perspective on a Pedagogical Architecture to Requirements Engineering Education: A Qualitative Study

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Abstract Given the fundamental connection between requirements analyst training and high-quality software development, the disparity between requirements engineering (RE) education in academic institutions and the software industry needs is an ongoing concern. In this context, the conceptual framework of Pedagogical Architecture (PA), which organizes educational practice using digital technologies, is an alternative to enhance RE teaching and learning. We developed a PA for RE education to aid in directing the development of hard and soft skills crucial for field practitioners regarding requirements specification and validation. This paper describes a qualitative analysis from the professors' point of view who reproduced our PA, using Grounded Theory procedures as a data analysis technique. Three educators who have instructed four iterations of RE courses in higher education, following the guidelines set down by the PA, were questioned. The analysis confirmed that the PA assisted educators in working on practical tasks, incorporating hard and soft skills in line with RE professional practice. Moreover, the PA increased student participation and engagement and made educators aware of the value of support materials for replicating the PA.

Keywords: *Requirements Specification, Requirements Validation, Pedagogical Architecture, Undergraduate Education, Qualitative Evaluation, Grounded Theory*

1 Introduction

Software development has steadily advanced its understanding of the Requirements Engineering (RE) process [Morales-Ramirez and Alva-Martinez, 2018]. RE has long been recognized as a critical component of software project success [Hofmann and Lehner, 2001], and with the industry's explosive growth, its importance has grown even more, making RE instruction essential in computing higher education [Javed *et al*., 2022].

The goal of RE is to ascertain the requirements of users for a software product by first identifying the needs of stakeholders [Lazo *et al*., 2020], which is a process that can be challenging for requirements analysts. Considering that 83% of faults occur before the coding is ever written, there is a clear discrepancy between the professional skills required of requirements analysts and the desired quality of the software product [Tockey, 2015]. Therefore, the RE activities must be correctly completed by trained people in order to produce high-quality software.

Tockey [2015] addresses how professionals being trained at universities are insufficiently prepared to handle the demands of the software industry. Ferreira *et al*. [2018] further emphasizes how theory and practice are not in sync. Because of this mismatch between the skills acquired in academics and what is needed in the job market, recent graduates find it challenging to launch their careers [Garousi *et al*., 2020]. As a result, the teaching-learning process is impacted by the lack of cooperation between these two sectors, demanding the adoption of techniques to establish a link with the professional practices [Martins *et al*., 2021].

The Requirements Engineering Education (REE) research area aims to increase the quality of courses linked to RE [Ouhbi *et al*., 2015] or the application of RE techniques in businesses [Regev *et al*., 2009]. Therefore, to ensure its effectiveness, RE teaching needs to balance a solid knowledge base with more realistic, practical experience, providing a comprehensive view of the software development process [Reißing, 2024].

Consequently, this field has been showcasing its potential by stimulating conversations that help ensure students receive a strong education in RE, preparing them for careers in the software industry [Idri *et al*., 2012; Javed *et al*., 2022]. Better software development processes can result from enhanced REE, which can then lead to systems that have a higher likelihood of truly meeting the needs and desires of their clients and end users (see Minor and Armarego [2005] for benefits).

According to research conducted by Ouhbi *et al*. [2015], REE has not yet achieved its peak of maturity, and one of the main worries of the scientific community is that *teaching methodologies are still being proposed with almost any empirical assessment or validation studies in place*. The authors also noted that greater focus is required in these areas and that requirements formulation and validation are only beginning to receive some academic attention. Despite the passage of nearly ten years, Daun *et al*. [2023] claim that *there are few validations or evaluations among the many suggestions for tools and/or methods for teaching RE*, which indicates a wide range of approaches that can be investigated in RE.

As a result, one reason for this gap between universities and businesses is the lack of development of soft skills throughout academic training [Oguz and Oguz, 2019]. Soft skills are not given enough attention by academics in the

traditional educational approach, despite the fact that they are acknowledged as being beneficial professionally [Sedelmaier and Landes, 2018; Epifânio *et al*., 2019; Ouhbi and Pombo, 2020; Rahman *et al*., 2021]. Studies like Calazans *et al*. [2017] have demonstrated that, in addition to hard skills, RE job openings require a professional to have soft skills to collaborate in the high-quality software development process, which serves as further evidence of the significance of these abilities in RE. Since students should be aware of the social and technical problems involved in working in the field, REE must also entail building soft skills [Daun *et al*., 2021].

Another issue is the scarcity of pedagogical frameworks that underpin RE instruction, as evidenced by the fact that a large portion of the research on RE that has been done thus far has not included the idea of pedagogy [Daun *et al*., 2021, 2023]. According to this viewpoint, the idea of Pedagogical Architecture (PA) [Carvalho *et al*., 2005] has the potential to close this gap by enabling the development and support of digital technologies for pedagogically-based approaches [Mocelin and Fiuza, 2021].

In prior work, we presented the PA called "Requirements in Action" and described how it might improve REE [Santana *et al*., 2023a]. We specifically support requirements specification and validation activities by developing a PA that connects hard and soft skills needed for requirements analysts. We also discussed a method of assessing the PA from the students' viewpoint who used it [Santana *et al*., 2023b]. The students' reports of the PA's assistance in learning how to define and validate requirements – in the form of user stories and acceptance test scenarios, respectively – and their perception of the approaches' professional value were among the primary findings. Furthermore, the students expressed how the course encouraged the development of multiple soft skills, including communication and teamwork.

This paper extends the previous evaluation by conducting a qualitative analysis of our PA from the professors' point of view. To find out how our PA improved RE teaching, semi-structured interviews were conducted with three professors from four editions of RE-related courses. Data analysis techniques derived from Grounded Theory Glaser and Strauss [1967]; Stol *et al*. [2016]; Strauss and Corbin [1998] were applied. As a result, we draw attention to the value of instructional materials in replicating the PA's suggested activities and the advantages of a variety of practical RE activities, all of which are part of the PA's pedagogical structure.

The remaining of this paper is organized as follows: Section 2 presents a theoretical foundation about PAs; Section 3 points out related work; Section 4 describes a brief overview[1] about the "Requirements in Action" PA; Section 5 details the method used to carry out the qualitative analysis; Sections 6 and 7 present the results and discussions achieved with implications for research and practice, respectively; Section 8 presents threats to validity; and Section 9 provides conclusions and future work.

[1]A detailed description of PA can be found elsewhere [Santana *et al*., 2023a]

2 Background

A Pedagogical Architecture (PA) serves as a guide for technology-mediated teaching practices. Its idea is based on Paulo Freire's Pedagogy of the Question [Freire, 2011], which holds that students' inquiries and curiosity drive dialogical interactions between instructors and learners to acquire knowledge. In addition, the idea is entwined with Jean Piaget's constructivist principles [Piaget, 1936], which hold that knowledge is not only acquired through absolute certainty, but also through the necessity of new alternatives and dialogue [Carvalho *et al*., 2005]. Rereading instructional practices that are already more attentive to the perspective of learning is made possible by this convergence of epistemological paradigms [Carvalho *et al*., 2007].

A PA is included in the concept of an instructional model, claims Behar [2009]. With regard to the participants and the components required for its implementation, this idea seeks to direct the development of the curriculum and pedagogical methods. The author outlines the dimensions that are established in the four components of a PA, which are as follows:

1. **Organizational aspects:** involves the rationale behind the planning of the PA, including the organization of time and space, the actors involved, the teaching method, etc;
2. **Content aspects:** encompasses the instructional materials adopted, as well as the study activities that make up the content selected for the PA;
3. **Methodological aspects:** comprises the methodology used to develop the course, establishing the assessment procedures and forms of interaction/communication;
4. **Technological aspects:** includes the choice of a tool or virtual learning environment that enables the implementation of the PA.

3 Related work

Previous studies by Tavares *et al*. [2012], Marques and Tavares [2015], Chagas *et al*. [2016], and Costa *et al*. [2019] have reported on the creation of this model of pedagogical organization concerning the adoption of PAs produced in the field of Computing; nevertheless, these reports only include tool evaluations or have in-progress forms of evaluation. Although only Costa *et al*. [2019] describe a PA in the general domain of SE focusing on teaching modeling using the Unified Modeling Language (UML), the other three conducted their research in the realm of computer programming.

Specifically, the PA conceived by Costa *et al*. [2019] aims to teach systems modeling with UML, focusing on using the peer review technique as an active methodology to promote collaboration and critical thinking among SE students. The students used case and class diagrams, reviewing the work of their peers with the help of specific checklists. The evaluation with the students showed that the methodology facilitated understanding and contributed to a better understanding of the modeling concepts.

To date, we are not aware of any other PA created especially to address REE, and "Requirements in Action" is regarded as a pioneer in addressing this particular subject.

However, PA proposals are coming up more frequently. An example, Ribeiro and Pinto [2023] based on the idea of PA, sought to suggest ongoing professional development for instructors of basic and technical education in multiple Brazilian states aimed at teaching computational thinking. Even though the course students were given pre-tests and post-tests, the authors' analysis did not focus on the professors' perspectives on the implementation of a PA deployed in the classroom.

Biancardi *et al*. [2024] describe a pedagogical structure designed to develop computational thinking skills in primary school students. The proposed PA combines playful activities, such as games and problem solving, to introduce computing concepts in an accessible and engaging way. However, although computational thinking shows a growing interest in proposing PAs, the study did not experiment with the PA, and it is still necessary to collect evidence on its impact.

In addition, Portilho *et al*. [2024] presented a pedagogical architecture designed for teaching programming logic, implemented in a university extension project. The proposal aimed at high school and undergraduate students to facilitate understanding of initial programming concepts. After completing the activities, the PA was evaluated using questionnaires explicitly applied to the participating students. The evaluation with the students revealed that the pedagogical architecture facilitated understanding programming logic concepts, promoting engagement and active learning. Most students rated the methodology positively, highlighting the accessibility and effectiveness of the proposed activities. However, the professor's perspective was not the subject of research.

The novelty of this study is that it presents a qualitative analysis that explains the opinions of educators when using a PA designed to teach RE, unlike other related studies. Furthermore, it should be mentioned that the viewpoint of the instructor as the personification of a PA was not examined in any of the research referenced. Consequently, our goal is to analyze this aspect by looking at the opinions of three professors in charge of teaching four RE courses about the usage of a PA in REE. We believe that future research that looks at similarly applying PAs can use it as a guide and potentially validate this suggested pedagogical organization.

4 Requirements in Action

To gain an understanding of the PA that the authors envisioned, we provide below an explanation of the "Requirements in Action" PA along with information about how it is replicated in higher education computer courses.

4.1 Definition of the PA

The "Requirements in Action" PA was created to help teach software requirements topics in undergraduate computer science courses. It plays the role of a guideline for approaching RE through the adoption of practical activities. Based on the alignment between the specification and validation of agile requirements, user stories and acceptance test scenarios were defined as the focus of the teaching activities, based on the literature on frequently used techniques in the software industry [Benitti, 2017]. The PA also intends to offer students with soft skills, which are considered important for carrying out the RE process [Calazans *et al*., 2017; Barbosa *et al*., 2025].

The goal is to initiate the teaching-learning process for software requirements, beginning with the creation of user stories. These stories will be reviewed, rectified, and modified before being verified using acceptance test scenarios in a six-stage dynamic plan, as shown in Figure 1. To do this, students must practice soft skills, which, when combined with the other items indicated, will serve to equip them with key skills for professional practice in RE.

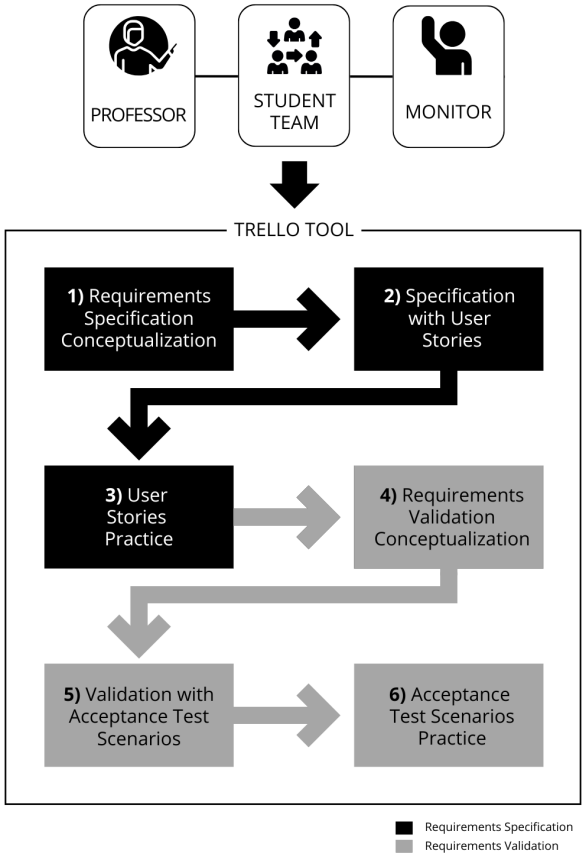

Figure 1. Stages of the PA and the actors involved.

In **Stage 1**, students are introduced to the ideas of requirements definition through at least one instructional lecture, preparing them for practical tasks after selecting software projects, whether fictitious or not. In **Stage 2**, group practice on user stories begins, starting with an example of a library system. The Trello[2] tool is given as the environment for carrying out specification activities. In **Stage 3**, each team begins working on the requirements specification for their projects, where their peers collaborate to correct the work. For each user story generated, a checklist of best practices must be followed, including items specified in the tool and priority labels. When finished, another group assesses the work, giving suggestions on the cards to help improve the artifacts. Similarly, in **Stages 4**, **5**, and **6**, requirements are validated using acceptance test scenarios.

With each feedback and activity update, the teams give

[2]https://trello.com/

the most recent version of the artifacts, particularly the cards themselves, which are modified and updated in the Trello application. The entire process is carried out using a cooperative learning approach, in which members of each team collaborate to attain a common goal. Furthermore, throughout the stages, the professor encourages critical reflection and assists teams in improving their work. It is also vital to emphasize the role of a monitor during the course, which assists the professor in guiding and mediating knowledge, for effective class monitoring, and as an assistant in conducting the PA between the various groups.

To the best of our knowledge, "Requirements in Action" is the first PA oriented for REE. The stages in Figure 1 show how it differs from traditional classes, with the interaction between students, monitors, and professors. All those actors are supported by a digital technology (i.e., the Trello tool) that allows collaborative interaction in a single environment: project scope definition, requirements specification as user stories, and acceptance test scenarios for each story produced. In a project-oriented learning approach, which is core of our PA, those actors are immersed in practice, in which students carry out activities and get feedback from both their peers and the professors and monitors.

Our PA's pedagogical aspects include interactionist-problematizing dynamics, distributed pedagogical mediation, and procedural and cooperative assessment of learning. It involves carrying out knowledge consolidation dynamics and the team-based development of a software project, considering deliveries that will be continuously reviewed, including by peers. Regarding pedagogical mediation, as reviewers of their colleagues' artifacts, students build their own knowledge and also contribute with the collective knowledge.

Figure 2 depicts an example of the final framework developed through actor interactions. Santana *et al*. [2022, 2023a] provide more information about the design of this PA.

4.2 Application of PA in disciplines

The PA was implemented in four disciplines during 2021/2, 2022/1 (twice) and 2022/2. These disciplines were "Requirements Engineering" and "Software Requirements", both with a 64-hour total workload and taught in the 7th semester of two higher education courses in the area of Computing (Bachelor's Degree in Computer Science and Bachelor's Degree in Software Engineering) at the Informatics Institute of the Federal University of Goiás (INF/UFG). The last application of the PA described in this study finished in February 2023.

To this end, customized lesson plans were drawn up for the specification and validation units, consisting of 1 hour and 40 minutes each (2h/lesson), aligned with each stage, to support professors in implementing the PA. All the plans were previously made available to the professors and are currently publicly accessible on a website[3], also including a set of related slides for each lesson and video tutorials to help with the use of Trello.

[3]Available for access at: https://sites.google.com/view/requisitos-em-acao/

5 Research method

The method adopted in this research was qualitative, with a view to understanding professors' perceptions of the "Requirements in Action" PA. To this end, semi-structured interviews were conducted and data analysis was based on Grounded Theory procedures focusing on the open and axial coding stages.

As already been pointed out, a previous study [Santana *et al*., 2023b] focused on carrying out a quantitative analysis from the students' point of view and, therefore, this work will only report on the qualitative analysis of PA. Therefore, the steps required for its analysis with professors are detailed in the following subsections.

5.1 Research questions

In order to carry out a complete analysis of the PA developed, as a differentiator from the other existing PAs reported in the literature, we sought to answer the research questions defined in this subsection. In order to define them, we adopted the strategy established by the Goal-Question-Metrics (GQM). The GQM paradigm is an objective-oriented approach to measuring and evaluating products, processes or resources [Basili and Rombach, 1994]. Proposed in the 1990s, it represents a generic measurement methodology in the SE area. The model starts by establishing the objective of the study, raising questions that address these objectives, while identifying metrics that can provide answers to the questions outlined.

Thus, the preparation of the GQM plan can be summarized in two steps: i) definition of the evaluation objectives (detailing the object of the study, purpose, quality focus, point of view and environment); ii) preparation of the GQM plan (which includes the preparation of a set of questions) [Gladcheff *et al*., 2002]. Therefore, the GQM was adopted to structure the research and help draw up the interview guide, as done in the work of Machado *et al*. [2021].

In this sense, the evaluation objective of this research is described below according to the GQM paradigm – with a structure analogous to that carried out by Gladcheff *et al*. [2002].

- **Object of study [what will be analyzed?]:** requirements specification and validation teaching strategy, which applies a PA called "Requirements in Action";
- **Purpose [why will the object be analyzed?]:** to characterize the perceptions of the professors who have applied the pedagogical strategy defined by the PA;
- **Focus of quality [property of the object to be analyzed?]:** characteristics related to organizational, content, methodological and technological aspects [Behar, 2009], related to the strategy for applying PA, as well as aspects related to the promotion of soft skills;
- **Point of view [who will use the data collected?]:** specialists (professors) in the field of RE;
- **Environment [environment in which the analysis will take place?** INF/UFG (place of work of the specialists and department where the disciplines were taught).

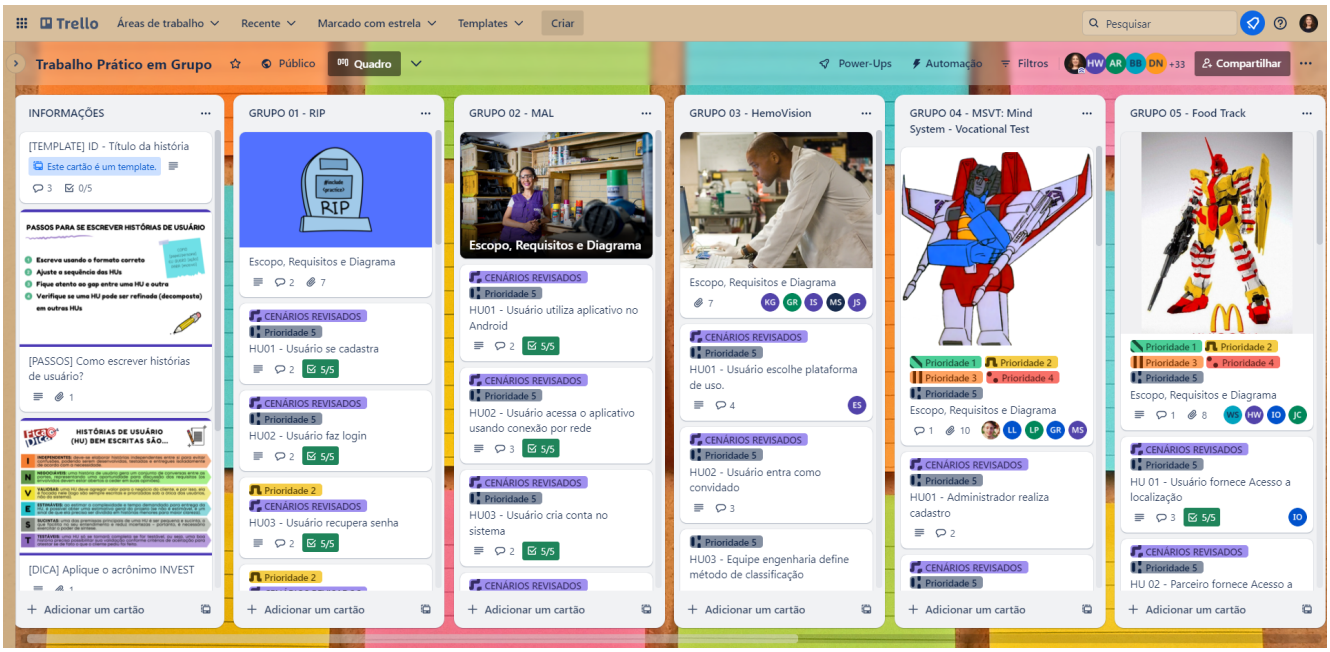

Figure 2. Trello depiction with final board created for the Bachelor of Computer Science degree in 2022/1 (in Portuguese).

Starting with the definition of the evaluation objective, the GQM plan established the questions to be analyzed. Since the interviews were analyzed from a qualitative perspective, no measurement metrics were established beforehand, and the GQM was therefore adapted to the analysis objectives. Our study was structured in a similar way to that carried out by Conte *et al*. [2009], applying the GQM with subsequent qualitative analysis adopting Grounded Theory.

The questions to be answered by the qualitative analysis are presented below:

- **Q1:** Does the strategy for applying PA meet the formative intent of RE disciplines?
- **Q2:** Do the teaching materials and activities provided allow the teaching strategy to be implemented?
- **Q3:** Do the methods defined by the PA when conducting the strategy contribute to the teaching-learning process?
- **Q4:** How do the technologies used support teaching practice?
- **Q5:** Does the teaching strategy contribute to the promotion of important soft skills for the professional performance of requirements engineers?

5.2 Data collection

Figure 3 summarizes the activities carried out during the data collection stage. The semi-structured interview was used as a data collection tool. Even though it refers to the apparent naturalness of a conversation, it is a systematic technique that differs from an intuitive conversation, focusing on methodological planning to meet the research objective [Leitão, 2021].

An interview can take on one of several classifications, depending on the level of freedom the researcher has to ask questions according to a pre-defined script [Leitão and Prates, 2017]. Thus, we opted for the semi-structured format, which is recurrent in Computing research and allows a certain spontaneity to explore meanings not initially foreseen [Leitão, 2021; Leitão and Prates, 2017]. Therefore, even if there is an interview guide, this does not prevent the conversation from following a natural flow and therefore it is not mandatory for the questions to be asked in the exact order in which they are listed [Wohlin *et al*., 2012].

This way, four interviews were conducted with three professors who taught RE disciplines. One taught two disciplines simultaneously for different courses and was interviewed twice. All the participants voluntarily agreed to take part in the interviews, and their identities were guaranteed confidentiality throughout the process.

For each interview, an interview guide was drawn up as support material, which included 28 questions[4]. The questions were designed to comply with the planning established by the GQM method, divided into thematic blocks and associating each question with a set of questions. The script was constructed in an iterative process, so that the questions could express an analysis that generally covered the breadth of PA and its various aspects, including the issue of soft skills. The script was validated by a researcher specializing in qualitative studies before being applied to the people interviewed.

The interviews took place in the second half of February 2023, after the end of the 2022/2 academic semester. For each discipline covered, the researcher contacted the professor personally, explaining the research's importance and the interview's purpose. Once they had given their consent to take part by signing an informed consent form, possible dates and times for scheduling the interview were checked and, based on the participant's responses, an invitation email was sent linked to Google Calendar[5].

Due to the ease of recording via web conferencing platforms, it was decided to use the Microsoft Teams[6] tool to conduct the interviews. Teams was chosen due to its availability

[4]Available at: https://zenodo.org/records/10673784
[5]https://calendar.google.com/
[6]https://teams.microsoft.com/

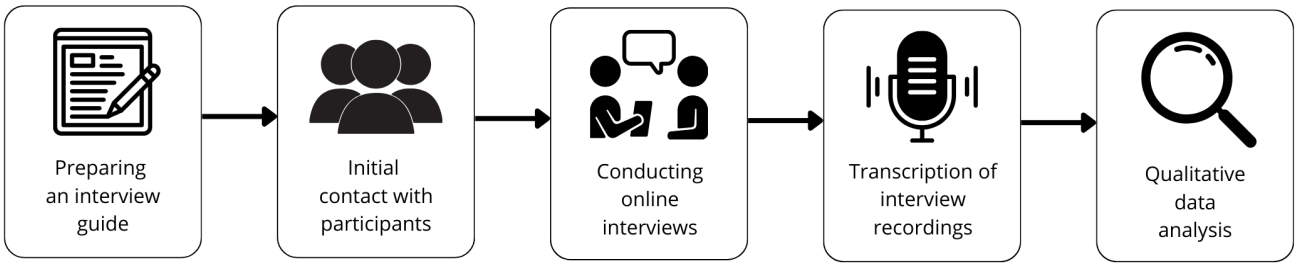

Figure 3. Activities carried out to obtain data for the PA's qualitative analysis.

for recording audio and video free of charge and without time limitations, when using the institutional e-mail address.

At the start of the interview, the research objectives and the voluntary nature of each professor's participation were recapped, explaining the ethical precautions. The researcher asked for verbal authorization to record the interview, and if allowed, the conversation began. No participant refused to continue with the interview.

Random codes were generated for the interviewees, represented by D1, D2, D3 and D4. This was done in order to keep the identity of the respondents confidential, without following the chronological order of the disciplines taught, given that each interview represented an instance of the application of PA. The average length of the interviews was around 59 minutes, with the shortest interview lasting 42 minutes and the longest 1 hour and 11 minutes.

With the four audio and video files generated by Teams, we moved on to processing the data – starting with transcribing them. To help speed up this process, we enlisted the support of the Reshape[7] transcription platform, which uses artificial intelligence for audio transcriptions. Because it was created in Brazil, it has good accuracy when transcribing audio in Portuguese (the language in which the interviews were given).

After the automatic transcription provided by the platform, the researcher reviewed each of the transcriptions, listening to the recordings in full at least twice to check the transcribed data, altering and correcting the terms that had been misunderstood by the algorithm.Finally, a file in *.docx* format was made available for download. In all, 57 pages of raw data were generated and made publicly available on Zenodo.

5.3 Data analysis

The qualitative analysis investigated the responses from four interviews with RE professors, with the aim of answering the questions previously defined within the GQM paradigm. The data analysis made use of Grounded Theory methodological procedures. This method has gained particular prominence as it offers a suitable methodology for addressing social, cultural and human aspects within SE, reflected in the rapid growth of its use in the area of Computing, as observed by Stol *et al*. [2016].

The Grounded Theory has several strands that can be adopted in qualitative studies. After the seminal publication of Glaser and Strauss [1967], it evolved to the point of giving rise to different variants [Stol *et al*., 2016]. In this study, we adopted the Straussian line [Strauss and Corbin, 1998], which systematizes the method of data collection and analysis with well-established steps. It also allows a research question to be defined prior to carrying out the Grounded Theory, and for support from the literature during the [Stol *et al*., 2016] process, with coding being divided into: i) open; ii) axial; iii) selective.

During the open coding process, after a detailed reading in search of relevant information in the texts, the data fragments are associated with quotes. Codes are assigned to these citations. A code makes it possible to name the phenomenon the researchers are interested in. Next, axial coding aims to identify the categories that bring together various codes, grouping them together and defining their relationships as the data presents itself. Finally, selective coding generates a central category capable of representing the main point of the study, which relates to all the other codes. This iterative process is completed when theoretical saturation is reached, i.e. when the addition of data does not produce new codes and/or interpretations [Strauss and Corbin, 1998].

According to Conte *et al*. [2009], the essence of the Grounded Theory method is that a theory can emerge from the data, i.e., that it derives from the information collected and analyzed in a systematic way. However, even though Grounded Theory is linked to theory building, researchers can make use of only some of its procedures in the data analysis process, in order to meet the objectives of their research [Strauss and Corbin, 1998]. As only one period of data collection was carried out, only the open and axial coding phases were adopted for the data from the four interviews conducted.

Thus, the open and axial coding stages, including the generation of networks of relationships, were carried out using the ATLAS.ti[8] tool, version 9. According to Moreira [2007], ATLAS.ti is one of the best-known and most robust pieces of software to use when analyzing data from qualitative research, and one of its features is that it allows you to interconnect the codes derived from the data.

First, the transcribed text was marked, giving rise to quotes containing the most relevant information that could answer the GQM questions. Codes were then created and assigned to represent a meaning for each highlighted quote (Figure 4). In this process, redundant codes with the same semantic meaning were found, which resulted in a reduction in the number of existing codes. Subsequently, groups of codes were also created, represented as categories which made it possible to aggregate the codes related to them. In this research, the categories were created according to the dimensions established

[7]https://www.reshape.com.br

[8]https://atlasti.com/pt

by Behar [2009] regarding the aspects that make up a PA, namely: organizational, content, methodological and technological aspects – in addition to including soft skills.

For a better visual representation, networks were generated for each dimension analyzed during axial coding. In this way, the existing relationships between the codes were examined, which are expressed through connectors available in the tool itself. It was then possible to define relationships of causal conditions, properties, parts, contradictions, among other indications, as suggested in Bandeira-de-Mello and Cunha [2003].

One researcher led the coding process and then the code segments were reviewed by another researcher, a lecturer specializing in RE. This validation stage led to a discussion about the codes obtained in order to eliminate inconsistencies, verifying the nomenclatures assigned in the open coding, as well as the connectors and relationships from the axial coding. After successive revisions, at the end of the analysis 93 codes were produced, associated with 12 groups (categories), which answer the questions established in the GQM plan for each of the five dimensions analyzed.

6 Results

The main findings and excerpts from the interviewees' speeches are discussed below, according to the dimensions of analysis established on a PA (Section 2). Quotations from the participants' speeches have been adopted to provide clues to the findings that allowed the teaching strategy to be evaluated from the higher education professors' perspective. The codes with the highest degree of magnitude (number of times a code was identified in the quotes analyzed) and those with the highest degree of theoretical density (number of relationships between a code and others) were highlighted.

Regarding the profile of the lecturers interviewed, all of them are working in university teaching, either in RE or even in related areas (such as the broad area of SE) and have/had contact with research and/or the market in this context. For each discipline taught to its respective class, one interview was granted, and so the same lecturer was interviewed twice due to having taught two disciplines in the same semester to different classes and courses. Further details are shown in Table 1.

Table 1. Interviewees' profile.

ID	Teaching experience	Research and/or market experience	Background
D1	17 years	7 years	PhD in Computer Science
D2	10 years	9 years	
D3	17 years	7 years	
D4	1,5 years	9 years	PhD student in Computer Science

6.1 Organizational aspects

The network created by axial coding (Figure 5) aimed to answer the question **Q1:** *Does the strategy for applying PA meet the formative intent of Requirements Engineering disciplines?*. According to Behar [2009], the organizational aspects are made up of items such as planning, organization of time, organization of space, actors and teaching modality – here represented as a group within the same network.

6.1.1 Planning

With regard to planning, it was found that the way in which PA was designed for software application **offers good coverage of the topics of requirements specification and validation**, as can be seen in Figure 5. In addition, it was pointed out in the interviews that this **planning focuses mainly on the practical part**, which is in fact well explored in the course of the RE discipline, as a strategy for working on theory in a reduced way. The following quotes confirm these issues regarding the distribution of topics and their relationship with practice.

> *"In relation to the organization of the classes for the face-to-face mode, I believe that everything was fine in terms of how the classes were planned, because they were so careful to cover, to leave time, even in the methodology, in the teaching plans, there is a suggestion of time for each part of the classes, within the stages of specification and validation, and they cover very well, adequately, even the part that needs to have theory so that the students understand what they will need to do."* (Professor D4 – Q1)

> *"Right, the discipline of Requirements Engineering, like many of these disciplines, it is important that you plan it well in advance, think about it and at the same time leave points where there is a certain flexibility, because it is a discipline that in my view has a lot of theory, but in the context of a single discipline, what is organized in a single discipline, I believe that the greatest focus should be on the practical part."* (Professor D1 – Q1)

In addition, it was noticeable that the **planning also proposes to carry out classes that are in line with the market**, in terms of the professional practices often adopted in the industry – highlighted in the following statement.

> *'[...] you have to focus on something and the objective was to put a strategy that was more in line with what we know is very much practiced, very much needed in the market, which was agile specification and validation."* (Professor D1 – Q1)

6.1.2 Organizing time

With regard to the organization of time, it was noted that there is a **distribution of time for specification and validation classes that is consistent with the rest of the discipline**. In this sense, the issue of allocating time in the classroom so that students can work on the proposed activities was pointed out. In addition, there was a code linked to planning (see Figure 5)

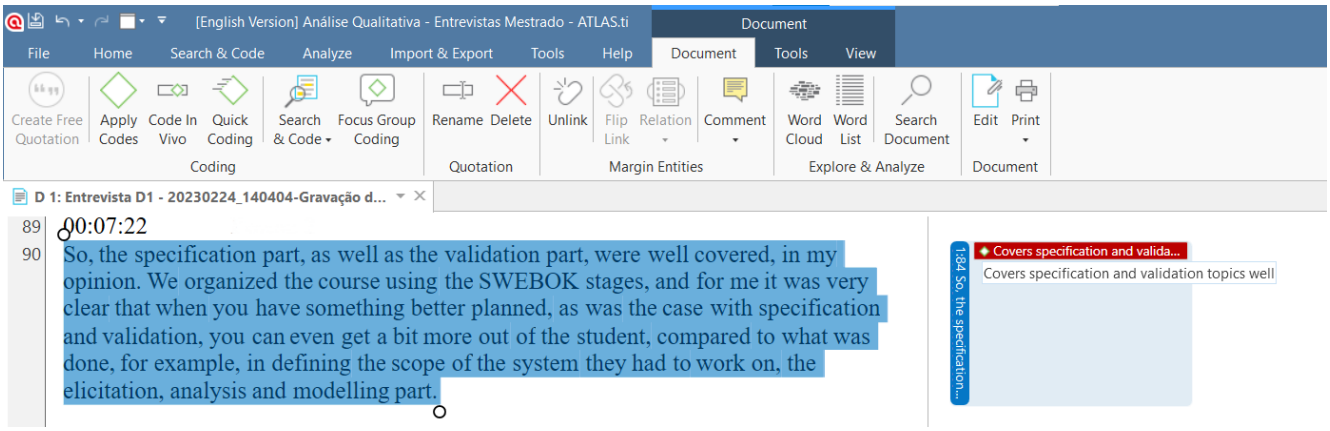

Figure 4. Example of open coding, assigning a citation to a code in ATLAS.ti.

that also stood out in this group: the coverage of specification and validation topics. These points can be confirmed in the following quotes.

> *"Right, I think that the planning, when I received the support material, the lesson plans, and I studied these lesson plans, I realized that they were quite correctly divided, in my view, in relation to the time I would need to teach each of the contents within the total time I have for the discipline. [...] So, the planning time was very consistent in my view with the period I had to teach this content and finish the discipline within the timeframe it offers me."* (Professor D4 – Q1)

> *"[...] but I think the way we had more practical activities and the vast majority of these activities were carried out in the classroom, right, and there were fewer activities to be done at home, right, to be handed in at the next lesson, I always said this to them, oh, do as much as you can here in the classroom and take advantage of the professor and the monitor. So, many of them, the vast majority, I think most of them took advantage of this."* (Professor D1 – Q1)

> *"I think I managed to apply the content well, both specification and validation. With these two topics, I think it was good."* (Professor D2 – Q1)

6.1.3 Organization space

With regard to the organization of the space, it was identified that the **availability of a laboratory is an essential factor in helping to carry out the practical activities proposed**, and its adoption allows good use to be made of the activities developed in the discipline. Therefore, there is a causal relationship (where the source code causes the destination code to occur) between the use of the laboratory in classes and good performance in the activities. At the same time, a factor related to the laboratory is the question of the organization of the machines, which traditionally occurs with benches lined up in parallel. From this perspective of arrangement, it was pointed out that there was a certain difficulty in interlocution, which possibly with another layout of the laboratory, could generate better use during the activities. The following statements reaffirm these indications.

> *"[...] So I think it would be essential for the discipline to be held in a laboratory, or at least for the groups to have access to a machine. What happens is that when it's in the classroom, which isn't a laboratory, we need the student to bring at least one laptop per group. When it's in the lab, it's easier."* (Professor D2 – Q1)

> *"To give you an idea, at times the students would stand up, right, and if it were any other kind of class, we'd make any kind of criticism, right, we'd say, oh, you can't stand up, people, oh, pay attention, no, the idea was exactly that, it was to stimulate this, that the person who's there on that bench, everyone together, working on the same job, on a bench, and sometimes the person at the other end had to stand up to contribute to the colleague there, to have a discussion, and that's what we want, right, we want the person to be able to interact there... Maybe a little bit, I think that in the lab, development is great, but maybe the way the machines are organized, right, in the lab could be different, so that people could really collaborate more easily, right, not bumping into monitors, bumping into cables, and that's normal, if they're benches, right, one in front of the other."* (Professor D1 – Q1)

In traditional computer labs, where this research was conducted, interactivity was only possible due to the arrangement that professors made in the in-person editions: students from the same group stayed on consecutive computers side by side. In addition, they were free to stand up to discuss the tasks presented on their peers' PCs/laptops. However, we believe that collaborative classrooms, which avoid rows of desks, would favor more interaction among students, with greater potential to improve soft skills. Collaborative classrooms accommodate small groups of students with flexible individual roles, with appropriate furniture for the construction of knowledge collectively, where the professor is merely the mediator between students and knowledge.

6.1.4 Actors

Analysis of the interviews identified the main roles of the actors involved, from the need for students to dedicate them-

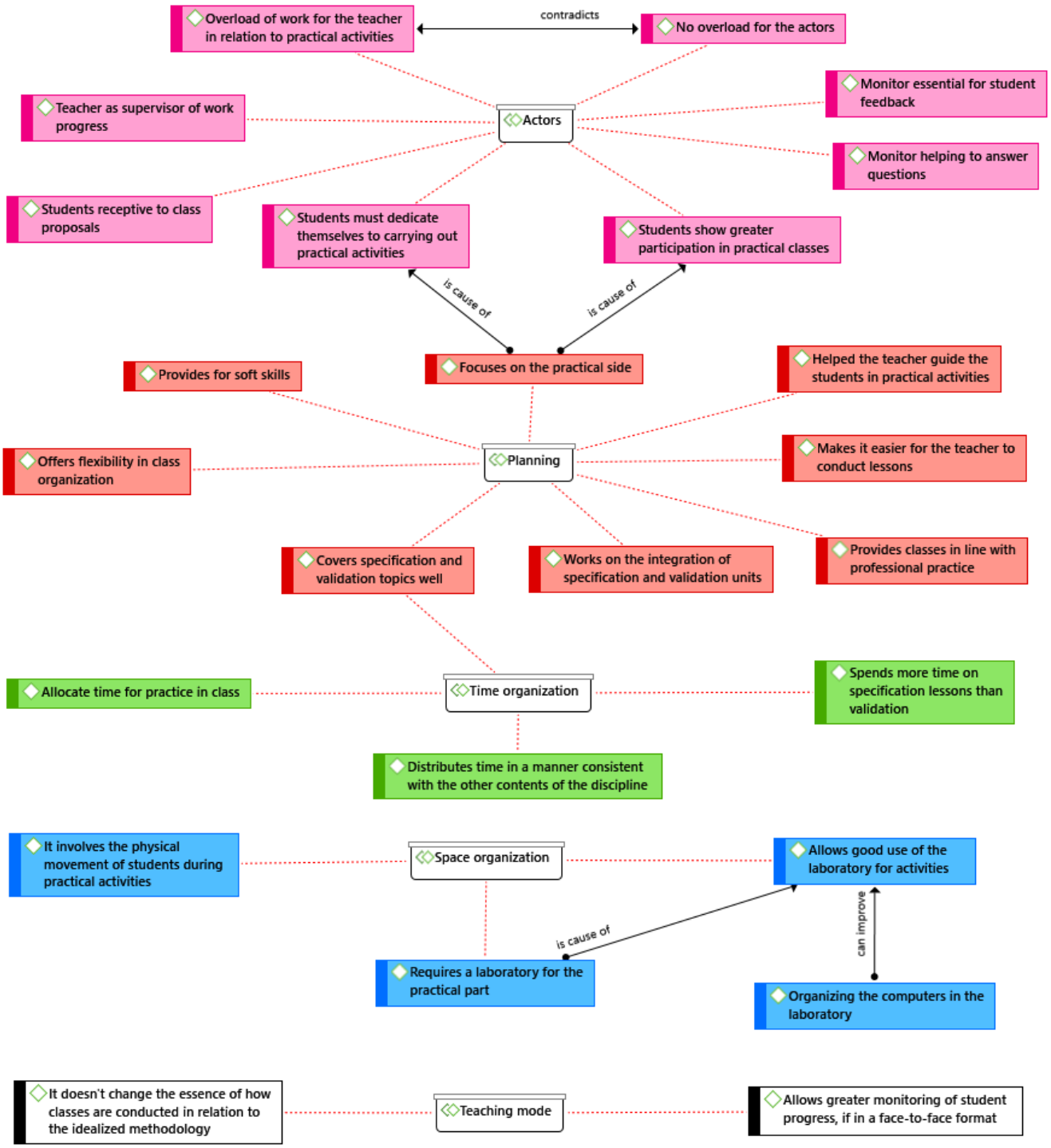

Figure 5. Graphic representation of the PA's organizational aspects.

selves to the practicals to the collaboration of the monitor in eliminating doubts. All of this was perceived by the professors, who also understood their role as supervisors of the work being carried out. Given the way we structured the PA, the students did not play the role of stakeholders, especially in terms of clients or end users. Although they were in charge of defining the project scope, this task was mostly assigned to the professor, who was responsible for guiding and questioning the students in defining the requirements and functionalities of the software considering a real context of use. In this way, the professors acted in a similar way to an experienced analyst, guiding the process and validating the results obtained.

An exciting relationship discovered was that, **because the classes focused more on the practical side, this established a causal relationship with greater student participation**. The same occurred about the need for student dedication, as shown in Figure 5. Another perceived relationship was a contradiction regarding work overload, which was evident for some professors considering the discipline as a whole within the scope of deliveries. Another interviewee said there was no overload for those involved, which may have been influenced by different ways of working on the previous phases of RE, such as elicitation and analysis, which PA does not cover. Below are the quotes that support these statements.

> *"And this course, the Software Engineering course, is a course that is eminently practical. The students are much more interested in the practical part than the theoretical part, that's quite evident."* (Professor D3 – Q1)

> *"So, since we had this division, even because of the proposed methodology, it already brings this division of having the theory part, yes, only very associated, together with the practical part and having a lot of practice time in the classroom, where the professor and the monitor can supervise and monitor the students' work in this practical part, I believe that this brought great success to the use of the discipline and I believe that for this semester the students' participation was very good."* (Professor D4 – Q1)

> *"So, the professor can handle 33 assignments, or eight assignments, right, for 33 students, every week, a discipline that she has consumed, but I think that, sometimes, it's the students' words, that this feedback is essential, it's their word. This feedback that you give all the time is essential, because we feel where we're going. We know where we're going and you help us to follow the right path and avoid the wrong one. And then the monitor is essential. So, in a discipline like this, with these characteristics, with this teaching strategy, I think the role of a monitor is extremely important."* (Professor D1 – Q1)

> *"The students didn't have many doubts during the process of making the specification and then validating it, writing the specification and validating it. So, I thought the division was good, it was smooth, it didn't overload, apparently it didn't overload the students and it didn't overload the professor or the monitor either."* (Professor D2 – Q1)

6.1.5 Teaching modality

As for the teaching modality, the interviews unanimously provided evidence that **the way PA is organized allows it to be reproduced in different teaching modalities**, without changing its essence. This can even be reinforced by one edition in which the discipline took place hybrid, with remote classes. However, it is believed that the professors' more effective support for students is better achieved through face-to-face teaching. The following statements highlight these perceptions.

> *"It worked, both remotely and in person, so there were no obstacles to the teaching modality."* (Professor D2 – Q1)

> *"Well, I think that the way it was planned and carried out, I believe that you could, it was 100% face-to-face, I believe that at times it could also be carried out remotely, it wouldn't have an impact on the way it was thought out, especially in those parts where you have a slightly more theoretical bias. There were very few classes, I don't have it off the top of my head, but maybe 3 or 4 classes that were more theoretical, and in the classes, mainly specification and validation, there was about 40 or 50 minutes of theory and then, at most, the rest was practical. So I think this more theoretical part could be taught remotely."* (Professor D3 – Q1)

> *'[...] the students are going to work and the professor is going to accompany them, is going to lead them, and this, for the face-to-face modality, I believe bears a lot of fruit, because in the remote model, the professor, despite being there together, wouldn't be able to get the same feedback, the same perception of what each group is doing, what each student is managing to do or not do, and provide the same assistance. So the face-to-face mode allows the professor to follow up better, receive better feedback from the students and be able to pass on better, better resolve the doubts and difficulties that arise from each class."* (Professor D4 – Q1)

6.2 Content aspects

Figure 6 presents the result of the analysis of content aspects referring to PA as a teaching strategy adopted by professors in RE disciplines. This dimension aims to answer **Q2:** *Do the teaching materials and activities provided enable the teaching strategy to be implemented?*. The groups were organized into teaching materials and study activities, both represented in the network created.

6.2.1 Teaching materials

The interviews emphasized that the **teaching materials have good documentation - which was cited as essential to guide the implementation of PA as a teaching strategy**. In addition, these materials make it unnecessary to create material, which causally helps to reduce the professor's overload in preparing lessons, as shown in Figure 6. In view of this, one point that should be highlighted is the **importance that**

Figure 6. Graphical representation of the content aspects of PA.

this material has for a professor who teaches the discipline of RE as a beginner. These issues are confirmed in the following excerpts.

> *"Look, as soon as I read this material, which was already ready, planned, I did it and I had no difficulties, I could understand at least 80% of what was in the document, and what I didn't understand, I asked the author of the research, who had proposed that strategy, so I think it was well suited, documentation is essential, documentation for me is essential, it really guides you in what you have to do and especially why you're doing it, because you define activities that need to be done, we're all professors, we know it has to be done, but it's just as important, if not more important, to measure how much of it you have to teach, so it's not just what, but how much, when and why. "* (Professor D1 – Q2)

> *"It helps a lot, because it's already ready, right, so the professor doesn't have to create material from scratch, so, for example, the cards are already ready, configured, with a design, with a nice font, well presented, with information that is necessary and quick for the group when they are doing the practice, for example, in Trello. So I think it makes the professor's life a lot easier."* (Professor D2 – Q2)

> *"But I think a bit of Trello as well, I mean, the approach of using Trello was a challenge at first. I think the materials and the guidance of the person who proposed the strategy helped a lot. If I'd gone it alone, it would have been more difficult. And I think that comes with practice, right? Using the tool for another purpose is a matter of practice. And if you have supporting documentation, which is what happened, it helps a lot. The descriptions in the professor's support material help a lot in this regard."* (Professor D3 – Q2)

> *'[...] especially being my first experience with the discipline of Requirements Engineering, as a complete isolated discipline, my previous experiences were Requirements Engineering within the discipline of Software Engineering, these materials, both the slides and the lesson plans, they greatly facilitated my organization, my planning for the discipline and made my experience as a professor much more pleasant and much simpler, I*

> *would say, if I were to compare, for example, with other disciplines that I had the opportunity to teach for the first time. "* (Professor D4 – Q2)

As for improvements, one interviewee pointed out that just as there is for specification activities on Trello, tutorial material could also be added for validation activities. This would help students to access support material without having to navigate other platforms (e.g. slides in virtual learning environments). In this sense, the development of a tutorial with operational tips for using the tool would also help to improve the way classes are conducted. These occurrences are reinforced by the following statements.

> *"Maybe put in the same material, as was done with the card template, as was done with tips for the user story, maybe add information there on the left, in the first column of Trello, as was done with the user story, also put in for acceptance test scenarios, so that they could also orient themselves, without having to leave Trello to look at slides."* (Professor D3 – Q2)

> *"[...] but if you can give operational tips, something like that, I think it helps a lot for the professor to make it tangible, how I'm actually going to do it in my day-to-day life, you know? [...] Because, for example, I taught this discipline in 2021/2, now I'm going to teach it in 2023/1. So two or three semesters have passed. I'm going to have to remember how I created Trello, how I set up the groups, I'm going to have to create these information cards. So, I'm going to have to create a new board from scratch for this new class, you know? So, this operational part, if I could make it easier for the professor, I think it would be very worthwhile."* (Professor D2 – Q2)

Considering this last statement, the **possibility of including material detailing the operational step-by-step of how to carry out certain actions in the tool used is important**, given that these may be tasks that the professor doesn't know how to carry out within the tool, even if they want to adopt PA. This vision came from one of the first professors who applied PA (i.e. in semester 2021/2), so the researchers had already realized this need, anticipating it in the **creation of the series of video tutorials, with technical tips on using Trello**. In this way, the videos meet the needs of professors in the practical sphere of classroom adoption, presenting a tutorial for using an example of a possible tool suitable for carrying out activities, explaining in Trello how to copy a board, how to share a board, how to add cover images to cards, among other items used in the PA "Requirements in Action".

6.2.2 Study activities

As for study activities, Figure 6 shows the **importance of student attendance at RE discipline classes**, especially when it comes to practical specification and validation activities. As each class is linked to evolutionary deliveries, which depend on cooperative teamwork, with specific instructions to be adopted in a tool, **absence has a direct impact on team deliveries in relation to the work under development**. Another interesting code that emerged from the data is the fact that the activities as they were conceived (with evolving deliveries, revisions, corrections between a group or even between different groups), can be **inspiration for adoption in other curricular components**. These indications are confirmed by the following excerpts.

> *'[...] this is a discipline that I think the guy shouldn't miss, because when he misses it, he loses a lot of information, he loses a bit of this follow-up, from a practical point of view, the theoretical part he runs after, but this practical part is where I think the icing on the cake is."* (Professor D1 – Q2)

> *"[...] this methodology didn't just help me in the Requirements Engineering discipline, but it ended up helping me to plan other disciplines that I also teach related to software engineering. So, I was able to take advantage of 100% of what the methodology proposed here for the requirements engineering part, and I was able to bring, transport many thoughts, many of these methodological ideas to the other disciplines, especially to the Software Engineering discipline."* (Professor D4 – Q2)

6.3 Methodological aspects

With regard to methodological aspects, the network resulting from axial coding (represented in Figure 7) was intended to answer the question **Q3:** *Do the methods defined by the PA when conducting the strategy contribute to the teaching-learning process?*. In this context, the assessment procedures and forms of communication/interaction were analyzed.

6.3.1 Evaluation procedures

With regard to the assessment procedures used during the instantiation of PA, the interviews indicated that they are in line with the **methodology proposed as a teaching strategy, and no modifications are necessary**. To this end, incremental artifacts are delivered iteratively between the specification and validation units. Furthermore, for all deliveries, with each new version, the previous work needs to be corrected. This was done taking into account the feedbacks of all the actors involved: professor, monitor and even other student teams (intergroups). In this sense, Figure 7 shows these relationships, where the codes on feedbacks from the professor and monitor, as well as the inter-group evaluation are part of the target code, which is made up of the combination of both. The following statements confirm this.

> *[...] I wouldn't change the assessment procedures, because I feel that the way the lessons were planned, the whole planning part was done in line with the forms of assessment that were proposed."* (Professor D4 – Q3)

> *"[...] and then at each iteration, it was an iterative and incremental work, the students would improve those deliveries, and the main point there was exactly the part that was up to specification and validation, where*

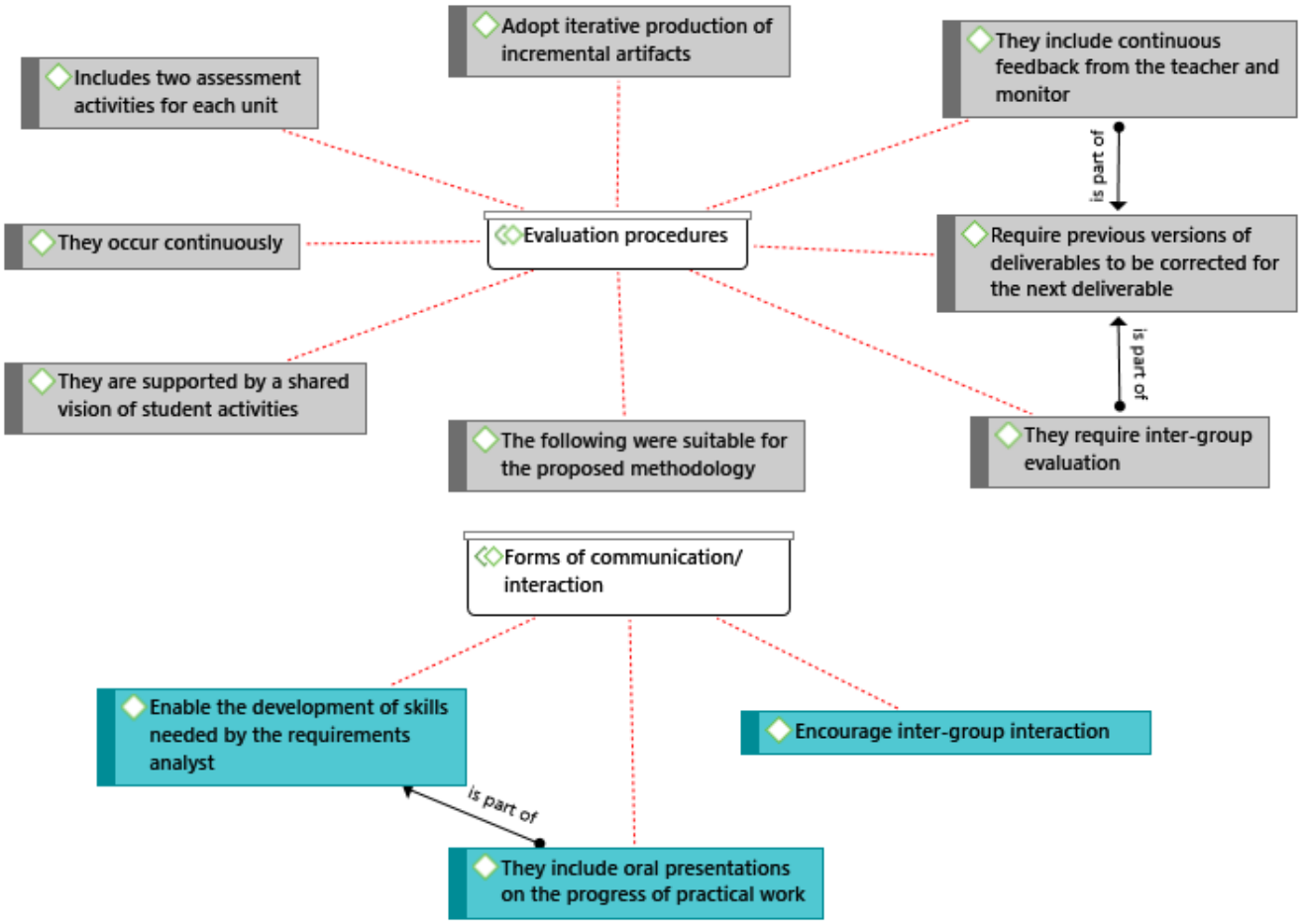

Figure 7. Graphical representation of the methodological aspects of PA.

they had to take all the work they had done, from requirements that were still very preliminary, a draft of the requirements, and from there, from the specification classes, they had to work on those requirements in the form of user stories, then augmenting those user stories with acceptance test scenarios." (Professor D3 – Q3)

"So, both internally, among the group itself, and also the possibility for them to see the evolution and work of the other groups, including being, being part of the evaluation, the correction, one group correcting what the other group wrote, what the other group specified and created as an acceptance test scenario later, this helped a lot in the maturing of the students throughout the semester." (Professor D4 – Q3)

6.3.2 Forms of communication/interaction

With regard to the forms of communication/interaction, they were worked on with a view to **developing the skills needed by a requirements analyst**, including even those of a non-technical nature. This was associated, for example, with oral presentations to explain the progress of the practical work (see Figure 7). Also noticeable was the encouragement of inter-group interaction, i.e. according to the modifications produced by one group in Trello, the others, upon seeing them, felt impelled to work in their groups as well, highlighting the **importance of a single vision among the groups beyond their individual work**. These assertions are reinforced by the following excerpts.

"And not just knowledge, but also skills. It was these skills that we wanted them to develop, to work a little more on communication. This current generation isn't very used to presenting a piece of work or a project. So we tried, as far as possible, almost always, to get them to work on verbal communication, to come forward, present their work, present what they had improved, what they felt they didn't agree with in the other person's work, because there was revision work, right? In some classes we worked on this, reviewing each other's work, and them giving their opinions, and giving their opinions in an informed way, having empathy with their colleagues, knowing that everyone there is part of a teaching and learning process." (Professor D3 – Q3)

"So, as one person looked at the other's board, I think that instigated them to write more requirements. And as the works were different domains, each group was a different domain, there was no way that one could copy from the other. So he could see his colleagues' work, so he'd go there and see, wow, my colleague has already done it, another group has already done 10 requirements and I've done 3, right? So he'd go and do more. So, this form of intrinsic communication between the groups, I thought was very valid." (Professor D2 – Q3)

6.4 Technological aspects

This dimension involves the digital tool used as an integrating element of PA, which is represented here by the Trello tool. Therefore, the aim is to answer **Q4:** *How do the technologies used help in pedagogical practice?*, with the network shown in Figure 8.

6.4.1 Digital tool adopted

Regarding the use of Trello, the interviewees' comments allowed them to identify a variety of customizable resources, including labels for prioritizing stories and controlling revised scenarios, as well as attachments, checklists and a template card – which **allowed them to use a tool that was not designed for working with requirements and was well adapted for this purpose**. All the items shown in Figure 8 linked to the available resources are parts that make up the target code (about the customizable resources).

In addition, the issue of **ease of visualizing requirements in columns was something frequently mentioned among professors**, which ended up causing a causal relationship with regard to a **better experience of requirements than a text document**. Even the fact that the tool provides a shared whiteboard, which allows a group of students to see their classmates' work, contributed to a **healthy dose of competitiveness during classes**. Below are the excerpts that support these perceptions.

> *"The features that the Trello tool offers are very suitable for working with this type of activity, both with the specification part and the validation part, because it allows me to customize, so it's a very dynamic tool, and this possibility it gives me of having a board feature, where I can allocate each group to a board, a list, and each member of the group can create their cards, and they can review, view the cards of the others, and all the groups can see the boards and the cards of all the other groups, this dynamic that the tool offers me, these features and resources that the tool offers me, it seems... We even think sometimes that it was a tool designed to do just that, that Trello's purpose would be to work with requirements, and in fact it's a tool with several purposes, but it's very well suited, as I said, to working with requirements engineering, especially when it comes to the specification and validation stage [...]."* (Professor D4 – Q4)

> *"For me, I thought it was much more, as I said, agile. The more interested students, before using this tool, I used to give them requirements specifications in a formal document, a text document, right? Word, that sort of thing. And I could see that the students didn't feel like writing. Collaboration was more difficult. So, one student couldn't see the other. So one group didn't know what the other was doing. And there wasn't that gameplay there, that desire to do more than the other group."* (Professor D2 – Q4)

However, since Trello is a tool that wasn't designed for this purpose, the professors pointed out situations that couldn't be done with it, or that could be improved, as described in the following statements. For example, one of the first professors to try PA pointed out the need to offer a way of copying the board with all the resources configured. This was corrected in subsequent editions with the idea of **templates with publicly available links**.

> *"The only thing, perhaps, that would be difficult would be to be able to print, for example, all the requirements at once, to generate a documentation of those requirements, right? Then it would be more difficult. So now I want to print out all these requirements, the details of these requirements. Then I can't. So that would be the only restriction I see in using Trello. But the way it organizes it, in cards, in boards, I thought it was very useful."* (Professor D2 – Q4)

> *"As a tool, Trello wasn't designed for this, but I think that with so many user stories, students sometimes don't give you a good visualization of the dependencies between these requirements. We know that a requirement has a dependency, you work on one requirement and it interferes with another, and that's something we haven't managed to work on. On the requirements management side, it wasn't possible to work on this. Perhaps we could think of a way of organizing these requirements in such a way as to show when they have a dependency between them. If you change one, it has an impact on the other, that would be an interesting view."* (Professor D3 – Q4)

> *"So, the very way the tool has been implemented allows us to reverse certain unwanted situations, although it could already have a way for me to block other people's edits at certain times. I think that's all I'd suggest improving in relation to shared work within the Trello tool."* (Professor D4 – Q4)

6.5 Soft skills

In addition to all the other dimensions already mentioned, one of the topics of the PA "Requirements in Action" was soft skills. Therefore, the aim was to answer **Q5:** *The teaching strategy contributes to the promotion of important soft skills for the professional performance of requirements engineers?*, encompassing the analysis of the following items: soft skills developed and soft skills cited as necessary in the face of industry requirements. The results of the network can be seen in Figure 9.

6.5.1 Soft skills developed

The interviews verified the **soft skills that professors perceived to be developed in students** during lessons, according to the format planned by PA. In all, 11 different soft skills were mentioned by the interviewees, as shown in Figure 9. Among the main ones, **teamwork and verbal communication, in fact emphasized in the lesson plans**, considering the very organization of the students into teams, as well as

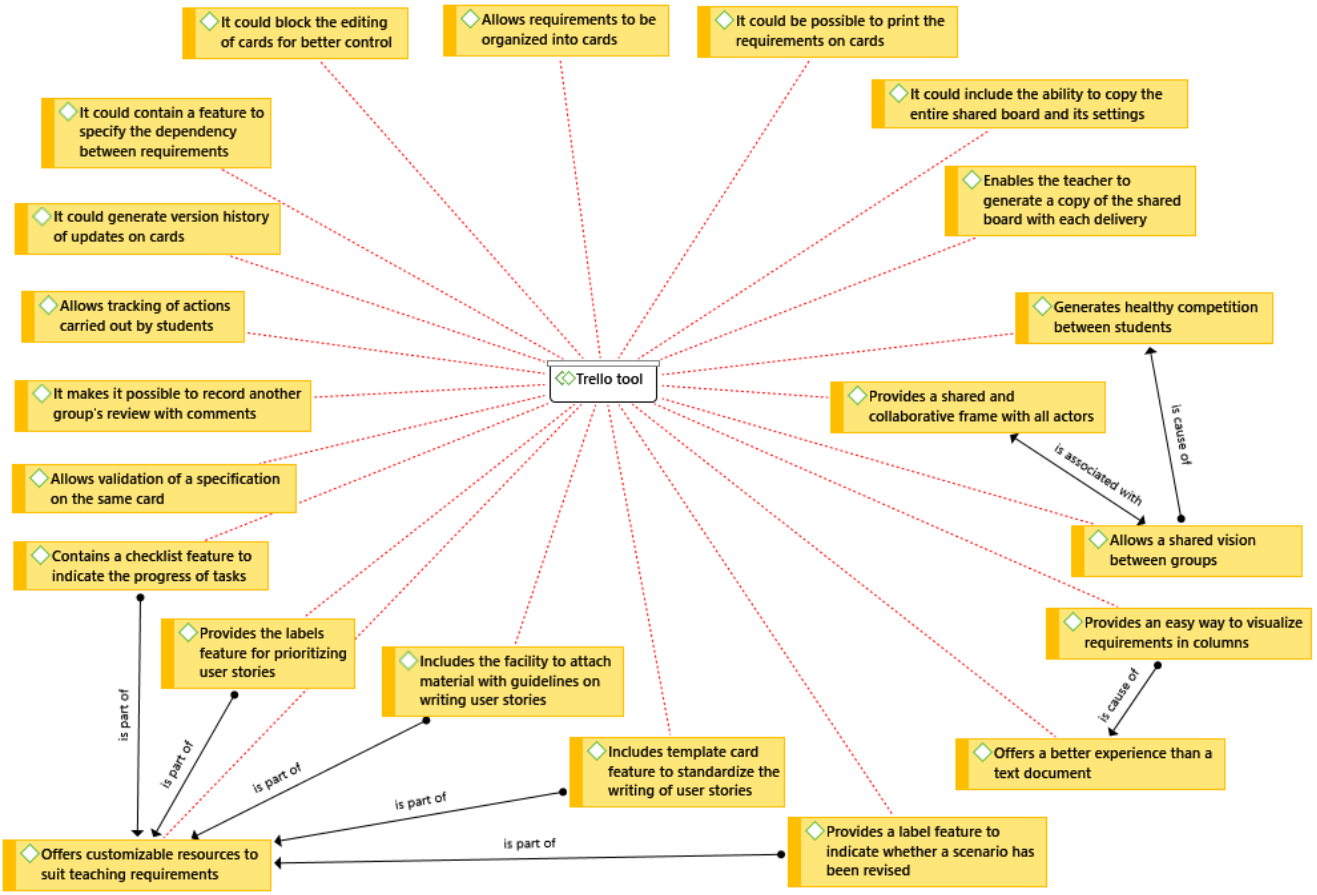

Figure 8. Graphical representation of the tenological aspects worked on in PA.

through the oral presentations required in the assessment procedures. These considerations are confirmed in the following excerpts.

> *"I think so. The main ones, I think, are teamwork, because they had to work as a team, right? The work was done as a team, not individually."* (Professor D2 – Q5)

> *"[...] you have to have other skills, you have to know how to speak. They realized, they said, you have to know how to present this. It's one thing what you write, but when you come here, you say something else. So, speak properly, don't speak informally. It seems a bit boring to us, but then it dawns on them that I'm presenting a paper here and I'm going to present it anyway. The guy pretends that you're presenting this project to the owner of the system, who's hiring you."* (Professor D3 – Q5)

Regarding the soft skills developed, our findings are focused on other notes in the literature. Barbosa *et al*. [2025], in a specific survey of software professionals in Brazil, listed the good attributes of RE practitioners. The authors pointed to skills related to verbal communication, such as talking to stakeholders, and business understanding, as part of the main attributes of great requirements engineers. Therefore, the PA enabled the development of soft skills that have been pointed out as some of the most important for carrying out RE activities. Furthermore, as Barbosa *et al*. [2025] reported, educators need to review their teaching methods in order to include practices aimed at developing soft skills, which this PA is dedicated to working on, combining aspects of technical training and social skills.

6.5.2 Soft skills needed in the face of industry demands

Developing soft skills during the course of the specification and validation classes was also related to those that a requirements analyst should possess, i.e. skills required in the industry that denote a good professional in addition to hard skills. At the same time, the following were cited as important: **job review, verbal communication, empathy, written communication, critical thinking, business understanding and teamwork** – soft skills which, according to the lecturers, were developed in the students (see Figure 9). Planning, organization, active listening, negotiation, curiosity and problem analysis and solution were also listed as important professionally, although they were not mentioned by the interviewees as developed soft skills. The following statements highlight the issue of the plurality of professionally important soft skills for the requirements analyst.

> *"But it's a person who has skill, good communication skills, it's a person who knows how to listen to others, it's a person who has a certain empathy, he can extract from there what the problem is that the person is describing, it's a person who has good written communication, right? Not just written, but also verbal, a person who has good negotiating skills, you often have to negotiate requirements, in short, a person who has to have critical thinking, exactly so that you can analyze whether what*

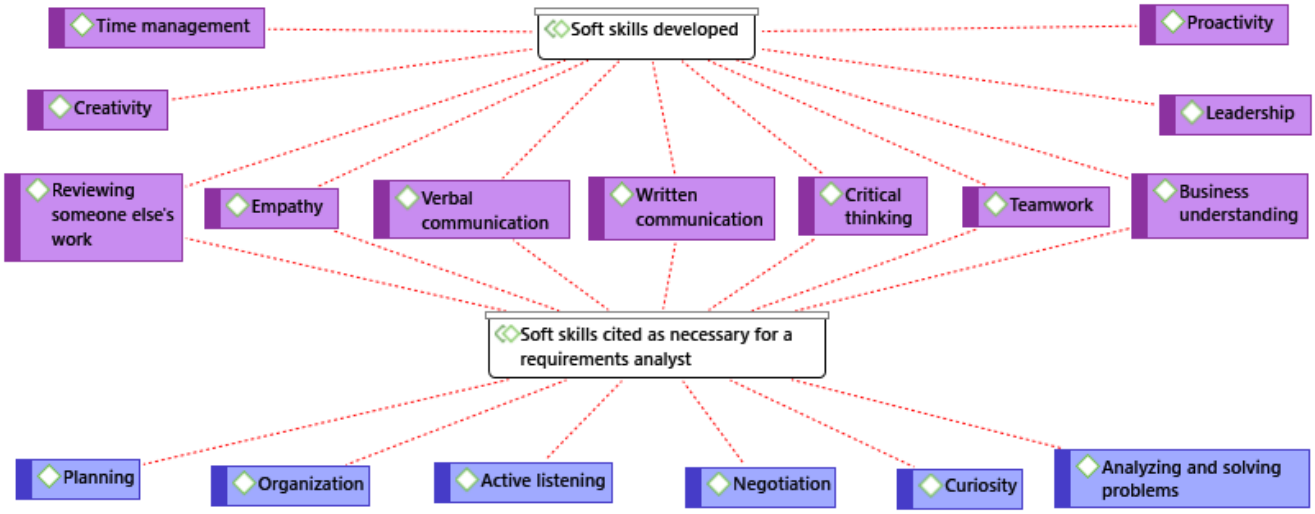

Figure 9. Graphical representation of the soft skills worked on in PA.

> *you're collecting, what you're analyzing really is a priority or not, you have to have teamwork skills, there's no way, and especially in multidisciplinary teams."* (Professor D1 – Q5)

> *"You have to have the ability to work in a team, because the requirements analyst, he then has to work together, he first has to work with all the stakeholders of the project, he then has to work with the tester, he has to talk to the designer, the developer, so he has to be good at communication, he has to be good at managing deadlines, because normally the requirements have to be done at the last minute, because otherwise he skips this stage and goes straight to development, so these soft skills are essential in the requirements analyst."* (Professor D2 – Q5)

Barbosa *et al*. [2025] cite that understanding desirable attributes for RE professionals can help improve REE. Therefore, PA as a teaching strategy that allows for the development of hard and soft skills represents a feasible way of working on these aspects beyond traditional teaching and, to this end, is based on active learning methodologies. In this sense, the practical work proposed is carried out mainly from the perspective of Project-Based Learning. The premise of this method is to choose a theme for a project – which involves choosing the team beforehand, determining the project period, using resources, and socializing the results achieved [Santiago *et al*., 2023]. Therefore, knowledge is developed through practical projects in an investigative process, with carefully planned dynamics, so that it was possible for the professors to provide a favorable environment for the development of those soft skills considered important for the software industry.

Complementary questions to the answers to the GQM questions unanimously pointed out that **professors who have implemented PA would recommend the use of the strategy by their peers**. One of the justifications for this is precisely the fact that the **contents defined by PA are practiced in industry**, and at the same time the professors perceive that **this organizational format has brought visible gains in learning and participation by the students** who have experienced the application of PA. In addition, having implemented the teaching strategy as established by PA made the professors rethink their teaching practices, both past and future, in which they highlighted the combination of PA and Trello as a strategy that has managed to attract the attention of students today.

However, the professors also commented that they felt a certain fear of applying the methodology proposed by PA, and that it was a **challenge to their professional practice as professors to change the way in which a discipline would traditionally be taught**. Therefore, this last item reinforces the need for pedagogical updating and continuing professor training policies, so that it is possible to evolve pedagogical praxis in a process of permanent improvement. In this sense, among several aspects, the **support provided by the materials helped to mitigate this challenge, given the level of detail available and their self-instructional nature**. The following is a collection of final comments aimed at confirming these perceptions.

> *"Yes, I would recommend it, as I said, for myself, it's something I'm going to continue adopting. I think the main feature, as I said, is exactly that for those two activities, specification and validation, you bring in content that has been practiced, is widely adopted in the market: user stories and acceptance test scenarios, which are practices in agile approaches such as BDD, so students are interested when they know that these things are used in practice. Professors benefit from already having material, a script, and a whole approach that is already very well worked out, both in the scripts and in the way Trello is used."* (Professor D1, additional comments)

> *"And it turns out that this new generation of students never seemed to be interested in this part of requirements and so on. And when a tool comes along, like Trello, which is considered an agile tool, right, and it comes with colors, it comes with... It's easy to drag cards around, it seems to speak the students' language more. So I think it was more... It was better accepted, better adapted to this type of teaching needed for this*

> *age, you know, of students."* (Professor D2, additional comments)
>
> *"Well, the biggest challenge, I think, is the issue of novelty. So this strategy was designed for specification and validation in an integrated way [...]. They were worked on as the projects were defined. I think the challenge was that you were trying this approach for the first time. The person who created the strategy, her proximity, reduced this challenge. The materials available reduced the burden that I would certainly have had if I didn't have this material, of understanding all this theory."* (Professor D3, additional comments)
>
> *"So, both for the instructor as a learner, especially in my case with little teaching experience, and for the students, I believe that there is a lot of learning in adopting this methodology. And I, not in my case, but I believe that even for an experienced professor, in order to update their methodology and requirements engineering techniques and ways in which requirements engineering also happens, this methodology that has been proposed makes an important contribution."* (Professor D4, additional comments)

7 Discussion

The PA was evaluated qualitatively by professors experimenting with this pedagogical organization format in the 2021/2, 2022/1, and 2022/2 semesters. The perceptions collected were derived from four editions of disciplines that focused on teaching RE, highlighting the interpretations and experiences of the professors involved, who agreed to reproduce PA within their discipline.

Professors understood that the PA explores content practiced in the market in an attractive way, corroborating this alignment of industry and academic expectations. Therefore, a practical approach that gives meaning to the students' theoretical studies on RE allowed them to remain receptive to the activities proposed in each lesson of the requirements specification and validation units.

To encourage the learning of RE topics, the greater focus on practical activities and their various benefits, such as greater motivation, participation, and student attendance during the development of the proposed work, was also pointed out. According to Memon *et al*. [2010], introducing RE concepts emphasizing practice favors the application of knowledge, resulting in better results than in essentially theoretical disciplines, which can make this discipline tedious and challenging to understand.

In addition, the professors recognized that soft skills are essential for the requirements analyst profession, with some of them developed directly and indirectly through how the teaching strategy defined by the PA was conducted. This assertion is reinforced in research by Calazans *et al*. [2017], which identified the profile of RE professionals according to job vacancies in the Latin American labor market, highlighting the importance of analytical thinking, verbal communication, and written communication, among other soft skills. In this context, the development of soft skills in PA is corroborated by practical activities that make students active in the teaching and learning of RE.

Professors also realize their role as mediators of learning, being one of the actors responsible for helping students to reflect critically. The professor plays an advisory role, especially when choosing project themes. During the four editions, the students worked on different software project themes, and within the same class, none of the projects had the same theme selected. Therefore, the professors reported that in this selection of fictitious projects, in the case of very disparate projects – where the team's knowledge of the subject was low, they acted constructively, urging the students to analyze whether this choice would be positive and how aware they were of the selected project. It should be reiterated that this advisory activity did not mean interfering with the student's creativity but rather a way of identifying possible bottlenecks before the practical execution of the activities to be carried out in the discipline. This step is of great importance, given the significant effort required of the professor, e.g., in a class of 40 students, where it is necessary to monitor several different projects feasibly and provide feedback.

The professors' reports made it possible to understand that detailed teaching materials that allow them to be reproduced are very important to achieving the objectives expected by PA. Therefore, all the materials developed (slides, lesson plans, Trello templates, video tutorials, etc.) were essential for each methodology chosen to be implemented as planned, whether it be class discussions or teaching-learning dynamics, among others, used with the PA.

Furthermore, the answers obtained in the interviews with the professors identified the main elements of PA, which included adapting Trello resources for teaching requirements in addition to the support materials already mentioned. In this regard, the professor modifies their teaching practice with the support of digital technology while seeing the results achieved through this transformation through the engagement reverberating in the students and their effective cooperation in the proposed activities. As pointed out by Silva *et al*. [2023], few PA studies are dedicated to promoting collaboration between students, which, in our PA, was worked on through all the stages.

However, the professors also commented on suggestions for improvement, most of which have already been taken care of as far as possible (considering the tool's limitations). Examples include organizing templates with model boards and operational video tutorials using Trello. At the same time, creating a website that collects all the artifacts related to PA is relevant, as it helps to ensure that PA can be reproduced in other contexts.

Therefore, given the professors' agreement and willingness to implement the PA in the curricular component they taught, their perception is a fundamental item in the analysis, allowing a more holistic view of the dimensions that make up the PA "Requirements in Action" – one of the differentials of this research about other studies of PAs in Computing. Therefore, observing the responses helps in understanding the aspects involved in the instantiation of a PA and helping to delimit possible modifications that complement the PA to improve its future execution in RE disciplines.

Based on these perceptions, we can also compare the findings described in the quantitative analysis with the [Santana *et al*., 2023b] students. Knowing that the PA was carried out with 7th-period students, i.e., most of whom are close to completing their courses, the students are mature enough to perceive hard and soft skills as necessary for their future professional performance, and that the PA helped stimulate these skills that bring them closer to the world of work. At the same time, the professors realized that they had developed industry-relevant skills, especially soft skills – which are not simply developed during traditional classes on technical content.

Furthermore, among the diversity of teaching-learning methodologies adopted within the PA framework, the students pointed out that project-based learning stood out the most. This is in line with the findings of the qualitative analysis, given that the greater focus on practical activities adopted by this methodology was of paramount importance for the instantiation of PA and, consequently, for generating greater motivation and class participation in the teaching of RE in the specification and validation units.

7.1 Implications for teaching, research, and practice

We believe that this study has implications that can help provide guidance both for academic professionals wishing to carry out new studies in REE, including initiatives involving PAs, and for the software industry professionals who live daily with the challenges of producing quality software.

Implications for RE teaching and research

1. The adoption of a PA represents the possibility of enriching pedagogical practice in the context of RE, given the series of benefits highlighted by this analysis (such as greater student attendance and dedication in classes, as well as content aligned with the professional perspective of RE), in addition to being an example of an approach that includes pedagogical bases in its conception – which according to Daun *et al*. [2023] is often ignored in contemporary REE literature.
2. It is essential to invest in professor training in order to improve the best existing pedagogical practices and methodologies for higher education.
3. Although it is not possible to state categorically that student performance has improved with the introduction of the practices proposed by PA, the experience of applying this teaching strategy is considered positive, given that it has helped to make the discipline enjoyable and dynamic for both students and professors – which, added to the fact that PA is reproducible and represents a feasible proposal to be introduced into Computing teaching.
4. As for the research methods used, our experiences describe a coherent analysis process, with a feasible example of how to carry out an evaluation process of this type of pedagogical structure. In our opinion, more studies must focus on this perspective to increase the number of experimental REE proposals.
5. The introduction of RE concepts should be better explored in Computing courses, and not only in the final periods, as was the case in the courses in which PA was introduced – we believe that the inclusion of the RE discipline, and consequently PA, in intermediate periods could favor integration with other disciplines, providing students with an integrated view of the software development process.

Implications for RE practice in industry

1. Requirements-related activities should be given more attention during the software development cycle, not only in terms of requirements elicitation and analysis, but also in terms of specification and validation activities, and even maintenance
2. Given that students and professors impacted by PA see the benefits of REE for the job market, the software industry is likely to benefit from training professionals who have rapidly developing hard and soft skills – making RE education increasingly relevant from an industrial point of view.
3. Employers and professionals in the field of RE should increasingly emphasize the importance of soft skills for good professional performance, so that it is possible to explore this aspect across the board in academia and the software industry, given the intrinsic relationship between training and software quality.
4. We hope that the organization in PA format will provide a useful guide on how to stimulate the development of soft skills that are important for requirements analysts and that need to be stimulated right from their academic training.
5. PAs have an evolutionary character, so it is important that current trends in RE practice can be investigated, considering agile methods and their developments, so that they can be incorporated into the practical activities proposed by this pedagogical structure.

8 Threats to validity

This section discusses on threats that could affect the results achieved in this work.

As for the subjectivity of qualitative research, which comes from both the data and the analysis carried out, statistics cannot be used to infer any results. Therefore, rigorous Grounded Theory procedures were adopted, considering the open and axial coding stages, which requires that the findings must actually emerge from the data analyzed, in order to reduce the subjectivity of the classification. Therefore, even though the coding stages were carried out by just one researcher, the codes and their relationships were validated jointly with another researcher afterwards. In addition, one of the authors has extensive experience in the use of Grounded Theory, having accompanied the process from the preparation of the interview guide questions.

Given the number of evaluators, it is not possible to generalize the results obtained for all REE contexts. Therefore, one of the threats to validity was the local scope of the

PA application, so that the perceptions collected are context-specific, restricted to our institution experience. However, data collected from the four editions of the RE disciplines bring contributions to an alternative way of teaching RE, as well as expanding a field of research into the use of PA for teaching software requirements.

Moreover, when working with human research, which involves subjective perceptions of the experience, the opinions of the participants can change over time. It is therefore necessary to expand the research to include a greater number of professors, including those from other universities and courses. This would increase the number of professors experimenting with PA, and even repeating previous participations, making it possible to obtain new relevant information about the instantiation of PA in different contexts.

9 Conclusions and future work

Ouhbi and Pombo [2020] point out that the use of new teaching methodologies has promoting a promising impact on students' learning experience in SE education. Particularly in RE, the PA "Requirements in Action" represents a pedagogical organization format evaluated in the light of quantitative [Santana *et al*., 2023b] and qualitative aspects. Regarding qualitative evaluation, professors' perceptions were investigated through using Grounded Theory procedures to understand the potential of the PA among the diverse set of existing strategies in REE.

As for the professors' main points, we can highlight the importance of detailed teaching materials, which allow PA to be reproduced through the teaching of RE. The professors also noticed that due to the greater focus on practical activities, there was greater student participation in the activities, which consequently highlighted various soft skills that were improved and/or promoted during the specification and validation classes. It should be noted that the Trello tool is an ideal example of a tool for conducting practical activities during the instantiation of PA. However, other tools with similar characteristics, with boards, cards and a shared environment that allows simultaneous work can easily be adapted to the PA "Requirements in Action".

We are aware that our findings are context-specific due to the low number of evaluators and RE disciplines. Consequently, the results and conclusions should be applied with caution in other contexts. However, the PA's goal is not to solve all the existing problems in REE, but rather to include and make available an additional pedagogical strategy, which has been empirically evaluated and has provided results that indicate improvements in the learning of hard skills required in the job market. The same happened with the soft skills, which through the teaching-learning dynamics, helped to promote teamwork, verbal and written communication, among others. Thus, the articulation between hard and soft skills in the design of PA is a possible strategy to address the training shortcomings pointed out by academia and industry. In this way, PA for teaching RE can contribute to aligning RE knowledge and the essential skills for training future requirements analysts. However, these contributions also extend to other computing professionals, given that learning software requirements contributes transversally to the software development process as a whole.

As lessons learned, we highlight the importance of making support materials available to professors, given the emphasis on lesson-by-lesson scripts for the correct implementation of PA and thus making it reproducible. In this sense, the website created for PA represents one of the most important elements in supporting the adoption of PA by other professors, by providing details that guarantee the possibility of its replication. In this case, we assume that the professor will be able to obtain the information available on the project's public website and be able to implement PA as a teaching strategy with complete autonomy. In this way, it will be possible to extend the qualitative analysis to other players at different levels, courses and/or teaching modalities.

As future work, we intend to examine the list of soft skills cited by professors as important for requirements analysts, identifying those that were not covered in the class scripts, so that we can verify ways of stimulating such skills within the execution of PA, thus making it possible to bring the needs of academia and the software industry closer together. Moreover, we intend to compare our results with literature work (i.e. Barbosa *et al*. [2025] among others) in order to reinforce our empirical evidence.

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Availability of data and materials

The datasets analyzed in this study are publicly available on Zenodo: `https://zenodo.org/records/10673784`. In addition, all the details about PA, including teaching materials and tutorials for professors, are available for access on its own website (in Portuguese): `https://sites.google.com/view/requisitos-em-acao/`.

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