

Investigating the Use of Research Software by Postgraduates in Computer Science

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***Abstract.** This article investigates the challenges and benefits associated with the use of research software by master's and doctoral graduate students in Computer Science. The study was conducted through a survey with 186 respondents, involving quantitative and qualitative data analysis. The results highlight difficulties related to the complexity of the tools, the learning curve, and integration with academic workflows. The research offers practical support for developers, institutions, and researchers, aiming at a more effective adoption of these technologies in the academic context.*

1. Introduction

Research software can be understood not only as computational tools for individual support, but also as collaborative systems that mediate interaction, coordination and collective production of scientific knowledge [Eisty et al. 2018a, Eisty et al. 2025, Hannay et al. 2009]. In contemporary academic contexts, especially in postgraduate studies, activities such as joint writing, task management, data analysis, organization of references and dissemination of results are carried out collaboratively, involving advisors, students and co-authors [Francese 2013, Katz et al. 2019, Speare 2018].

In this scenario, platforms such as Overleaf¹, Trello², Figma³ and other cloud-based tools play a relevant role in supporting academic activities, including writing, organization of references and task management [Adeyemi et al. 2020, Speare 2018]. In this way, research software plays a strategic role in the lives of researchers, contributing to the scientific community, developers and universities, while speeding up the dissemination of results, the management of references and the presentation of statistical data, promoting advances in scientific knowledge [Katz et al. 2019, Barker et al. 2022, Speare 2018].

Research software is a central component in contemporary research projects, encompassing tools, libraries and applications developed to support different stages

¹<https://www.overleaf.com>

²<https://trello.com>

³<https://www.figma.com>

of the scientific process, such as reference management, systematic reviews and qualitative and quantitative analyses [Nangia and Katz 2017, Eisty et al. 2018b, Eisty and Carver 2022]. Prior studies have investigated success factors, challenges and perceptions associated with the use and development of these software in the academic context, indicating gaps related to adoption, integration and institutional support [Francese 2013, Melles and Unsworth 2015, Mourão et al. 2024, Mourão et al. 2025, Mourão et al. 2023].

In the literature, studies investigate researchers' information seeking behavior and their use of digital tools and information resources in academic contexts [Niu et al. 2010, Nicholas et al. 2017, Hemminger et al. 2007]. However, there is a gap in the literature regarding the use of research software by postgraduate students in Computer Science, especially with regard to the challenges, barriers and benefits perceived from the perspective of academic collaboration. Given this gap, the general objective of this work is to answer the following research question (**RQ**): "*What are the challenges and benefits of using research software?*" In order to deepen the analysis and guide data collection, seven subquestions were formulated:

- **SQ1.** What are the most used and cited research software?
- **SQ2.** At which stage of research do postgraduate students most use research software?
- **SQ3.** What is the frequency of use for each stage of research?
- **SQ4.** How important is each of the following characteristics as a motivation for adopting the research software you use or have used?
- **SQ5.** What are the most sought-after requirements and features in research software?
- **SQ6.** Has the participant already used formal support or training to use the research software?
- **SQ7.** What are the challenges and barriers to using research software?

This article presents three main contributions. First, it provides empirical evidence on postgraduate students' use of research software. Second, it presents the adoption profile of these tools in the academic context. Third, it helps guide the adoption and more effective use of academic software by institutions and researchers.

The remainder of this article is structured as follows. Section 2 presents the related work. Section 3 describes the methodology adopted in this study. Section 4 reports the results obtained from the survey. Section 5 discusses the findings and their implications. Finally, Section 6 presents the conclusions, limitations, and directions for future research.

2. Related Work

Previous works investigated the adoption of software by researchers in different academic contexts, often addressing information behaviors associated with the search, organization and use of scientific information [Hemminger et al. 2007, Hendal 2019, Mourão et al. 2023]. Studies along these lines identify the use of research software over time, as well as the consolidation of digital platforms in academic life [Hannay et al. 2009, Nicholas et al. 2017, Katz et al. 2019].

Another relevant aspect focuses on the use of reference management software and bibliographic citation tools in academic environments [Emanuel 2013,

Nilashi et al. 2016, Adeyemi et al. 2020]. In this context, investigations with postgraduate students reveal the adoption of these tools, as evidenced by the reported use of reference management software among participants [Speare 2018, Francese 2013, Stefanovic et al. 2021]. However, the literature also indicates that the frequency of use tends to vary, often being associated with specific academic research tasks [Madhusudhan 2016, Sochat et al. 2022, Francese 2013]. Additional studies analyze factors related to retention in the use of these software after formal training, particularly in relation to tools such as EndNote [Melles and Unsworth 2015, Speare 2018].

Complementary research investigates the search mechanisms and access to scientific articles used by postgraduate students, providing insights into usage patterns, adopted strategies, and difficulties faced during the process of searching for scientific information [Gomes et al. 2018, Giordano and Biolchini 2012]. Despite the contributions of these works to understanding the adoption of digital technologies in academic research, there is a gap in the integrated analysis of the challenges faced by postgraduate students in Computer Science throughout the entire scientific workflow.

There is still a lack of studies that investigate the use of a broader scope of research software and the difficulties, barriers and benefits perceived in its adoption. This study advances in this direction by investigating not only what software is used, but also how these resources are incorporated into research practice, from the perspective of the postgraduate students themselves.

3. Methodology

This study adopted a quantitative and qualitative approach through a survey, with the aim of investigating the use, frequency, challenges, benefits and perceptions of postgraduate students about research software. The methodological design was structured into five main components: instruments, sampling, collection procedures, metrics and data analysis, and ethical considerations.

3.1. Instruments

The collection instrument consisted of a structured questionnaire, containing closed and open questions, prepared in Google Forms. The questionnaire was inspired by previous studies on the adoption and use of research software, being adapted to cover specific aspects of this work, such as frequency of use per research stage, motivations for adoption, desired requirements and challenges faced [Francese 2013, Speare 2018, Hannay et al. 2009, Katz et al. 2019].

The closed questions used the five-point Likert Scale, widely used to measure attitudes and perceptions [Joshi et al. 2015]. The open questions allowed participants to express themselves freely about the benefits, difficulties, technical barriers and limitations of the software used. All questions in the questionnaire, as well as the complete structure of the collection instrument, are available in a public dataset ensuring transparency and reproducibility of the research, accessible at [Y. Shigihara 2025].

3.2. Sampling

The study population consisted of master's and doctoral students in Computer Science in Brazil. This choice is justified by the gap between scientific computing and software

development in the market [Hannay et al. 2009]. In this context, scientific software development requires in-depth knowledge of the application domain, which positions postgraduate students in this space by integrating knowledge of the area and software development for research.

Sampling followed a non-probabilistic accessibility approach, considering access to participants through academic networks and institutional contacts. In total, 186 valid responses were obtained. The participants mostly belonged to the Southeast region of Brazil, followed by the Northeast, Central-West, South and North regions, reflecting the distribution of postgraduate courses in Computer Science in the country.

3.3. Data Collection Procedures

The questionnaire was disseminated by sending links via email to Computer Science departments, Brazilian universities and postgraduate students, covering both master's and doctoral students. The data collection period took place between February 2, 2024 and April 12, 2024. Participation was voluntary and respondents were not identified, guaranteeing anonymity and confidentiality. Before answering the questionnaire, participants were informed about the objectives of the study and the scientific use of the data.

3.4. Metrics and Data Analysis

Quantitative data were analyzed using descriptive statistics. The analyzes were supported by the Google Forms resources and Microsoft Excel for organizing data, building tables and generating graphs. No inferential statistical tests were used, since the objective of the study was essentially to characterize usage patterns and participants perceptions.

The open-ended responses were examined through thematic analysis [Braun and Clarke 2006] inspired by the works [Vasconcelos et al. 2022, Vasconcelos et al. 2024]. The process involved an initial and floating reading of the responses, followed by open coding of relevant excerpts, grouping the codes into categories and, finally, the synthesis of themes representing the challenges, barriers and perceived benefits. NVivo software was used to support the organization of codes, categories and relationships between emerging themes.

3.5. Ethical Considerations

The research involved administering questionnaires to postgraduate students about the use of research software, without collecting sensitive information. Therefore, the study qualifies as having minimal risk, in accordance with Resolution No. 510/2016 of the Brazilian National Health Council. All stages of the investigation followed the ethical principles applicable to research in human and social sciences.

Participants were informed about the study's objectives and gave their free and informed consent through the questionnaire itself, which contained the Informed Consent Form. Furthermore, their anonymity and confidentiality were fully preserved. The study was planned according to the procedures required for submission to a Research Ethics Committee, although the submission was not completed. These measures contributed to reducing ethical risks and strengthening the validity of the empirical study [Wohlin et al. 2012].

4. Results

The study included 186 respondents [Y. Shigihara 2025], mostly graduate students in Computer Science. A higher number of master's students were observed compared to doctoral students, as well as a greater concentration of participants in the 26-35 age group, followed by the 36-45 age group. Regarding regional distribution, most respondents were located in the Southeast region, followed by the Northeast and Central-West regions, with less representation from the South and North regions.

4.1. What are the most used and cited research software programs (SQ1)?

Table 1 presents the research software most cited by the participants. A predominance of tools focused on collaboration and support for scientific production is observed, with Overleaf (19%) standing out, followed by Trello (15%) and Jupyter (14%). This result highlights the centrality of collaborative environments for writing, organizing tasks, and analyzing data in the context of postgraduate studies in Computer Science.

Table 1. Most commonly used research software (multiple choice).

Software	Answers	Percentage (%)
Overleaf	156	19
Trello	127	15
Jupyter	116	14
Mendeley	86	10
Figma	77	9
Rstudio	77	9
Notion	72	9
Zotero	63	8
Parsifal	62	7
Total	836	100

Among the reference management software, Mendeley (10%) and Zotero (8%) stood out, corroborating findings from previous studies that indicate widespread adoption of these tools by postgraduate students [Adeyemi et al. 2020, Speare 2018]. The presence of these software programs reinforces the importance of bibliographic organization as a recurring activity throughout the research process.

Unlike investigations carried out in other countries, where EndNote shows significant adoption, its use was not very representative in this sample [Hendal 2019, Speare 2018]. This result suggests possible contextual differences related to access, cost, preference for free tools, or local strategies for adopting research software.

4.2. In which phase of the research do graduate students most frequently use research software (SQ2)?

Previous studies analyze the use of research software, particularly reference management tools, based on specific categories [Nilashi et al. 2016, Speare 2018]. In this study, the results highlight the adoption of these tools in different phases of academic work, indicating their pervasive role throughout the research process.

Table 2. Phase (multiple choice).

Phase	Answers	Percentage (%)
Study of literature	130	19.1
Data collection and organization	122	17.9
Data analysis	115	16.9
Planning and monitoring	111	16.3
Announcement of results	103	15.1
Conducting experiments and simulations	100	14.7
Total	681	100.0

Digital technologies are often adopted pragmatically to support logistical aspects such as information access and task management [Henderson et al. 2015]. The results presented in Table 2 reinforce this perspective, with higher usage in literature review (19.1%) and data collection and organization (17.9%), and lower usage in experiments and simulations (14.7%), suggesting that research software is more commonly applied to information management than to specialized tasks.

4.3. What is the frequency of use for each stage of the research (SQ3)?

The results indicate that the use of research software is more prevalent in the literature review and data collection and organization phases, with most participants reporting frequent or constant use. In contrast, in the planning and monitoring stages and in the execution of experiments and simulations, usage is more evenly distributed across frequency levels, with a higher proportion of occasional, rare, or non-use. In particular, the experimentation phase shows a more balanced distribution between frequent and infrequent use, suggesting a lower centrality of research software in this stage of the research process.

This study goes further by showing that the frequency of use of research software varies according to the stage of academic work. This result complements findings that analyzed the use of online citation tools in academic contexts and research practices [Madhusudhan 2016, Henda 2019, Speare 2018].

4.4. How important is each of the following characteristics as a motivation for adopting the research software you use or have used (SQ4)?

The results indicate that the adoption of research software is predominantly driven by pragmatic criteria, especially its free availability and perceived efficiency in carrying out academic activities. In contrast, attributes such as open-source software showed varying relevance, not proving to be decisive factors for most participants.

Institutional factors, such as the provision of software by the institution, its formal requirement, or the supervisor's recommendation, had limited influence on the adoption decision. These findings suggest that the choice of tools is based primarily on perceived usefulness and the researchers' own practical experience, rather than on institutional impositions or guidelines.

4.5. What are the most sought-after requirements and features in research software (SQ5)?

Studies focused on reference management software indicate that features such as usability, performance, support for citation styles, collaboration features, and integration

with word processors are commonly discussed as relevant factors in the adoption of these tools [Nilashi et al. 2016, Emanuel 2013, Francese 2013, Speare 2018]. Since the present study adopts a broader scope, involving different types of research software, additional requirements emerge that expand on previous findings.

Among the requirements most valued by participants, ease of use and efficiency stand out, corroborating previous results [Speare 2018, Nilashi et al. 2016, Emanuel 2013]. Usability is associated with intuitive interfaces and practicality, while efficiency relates to reliability and increased productivity. Aspects such as cloud usage, remote access, scalability, integration with other tools, and support for languages like R and Python were also recurring. Regarding functionalities, those focused on the organization and management of research stand out, such as reference management, study documentation, data categorization, version control and document standardization, as well as collaboration, search, and data analysis features.

4.6. Have you already used formal support or training to use the research software (SQ6)?

Previous studies indicate that graduate students require training and support for the effective use of research software, including instructional resources and guidance materials [Speare 2018, Melles and Unsworth 2015, Hendal 2019]. The results of this study show a balanced division between participants who had already participated in some tutorial, training, or course related to research software (49.6%) and those who had not had this type of training (50.4%).

This result may indicate that institutional training opportunities are not systematically available, which may influence user experience and be associated with technical difficulties or limited use of available functionalities, as discussed in the literature [Madhusudhan 2016, Sarrafzadeh and Khaleghi 2017, Francese 2013, Melles and Unsworth 2015, Speare 2018].

4.7. What are the challenges and barriers in using research software (SQ7)?

The literature points to the complexity of the tools, lack of training, and technical problems as recurring barriers to the use of research software [Melles and Unsworth 2015, Speare 2018, Francese 2013]. The results of this study corroborate these findings, highlighting the lack of training a difficulty faced by the participants.

Technical barriers are the most recurring group of problems, involving instabilities, interoperability limitations, compatibility issues, and support failures. These aspects indicate weaknesses in the technological infrastructure that supports the daily use of research software, especially in environments that depend on multiple tools for different stages of academic work.

The cost of software also emerges as a barrier, since commercial models often impose functional restrictions on free versions, requiring the purchase of licenses for full access to features. Furthermore, the fragmentation of tools used throughout the research hinders data integration and the management of the scientific process as a whole. Finally, difficulties related to usability and low visibility of relevant software limit researchers' access to potentially more suitable solutions, as also pointed out in previous studies [Hendal 2019, Sarrafzadeh and Khaleghi 2017, Francese 2013, Nitsos et al. 2022].

5. Discussions

5.1. Adoption Standards for Research Software

Previous studies often analyze research software in a segmented way [Nilashi et al. 2016, Speare 2018, Melles and Unsworth 2015]. This study shows that, in the context of Computer Science, these tools are used across multiple phases of the research process. This pattern reinforces findings that position research software not as isolated tools, but as structural components of contemporary scientific practice, permeating multiple stages of knowledge production [Hannay et al. 2009, Katz et al. 2019, Barker et al. 2022, Crouch et al. 2014].

The predominance of free access and perceived efficiency aligns with prior studies indicating that perceived usefulness and practical functionality are central determinants of research software adoption [Nilashi et al. 2016, Emanuel 2013, Hendl 2019, Madhusudhan 2016]. From this perspective, research software can be understood as a form of collaborative infrastructure that sustains distributed academic work, enabling coordination, shared artifact management and collective knowledge production [Hannay et al. 2009, Katz et al. 2019, Crouch et al. 2014].

5.2. Technical Barriers to Software Use

Technical barriers emerge as obstacles to the effective use of research software, involving instabilities, installation difficulties and interoperability limitations [Speare 2018, Madhusudhan 2016]. The simultaneous dependence on multiple software programs for writing, analysis, versioning, and project management increases operational complexity and raises the likelihood of technical failures and inconsistencies [Francese 2013, Nitsos et al. 2022, Melles and Unsworth 2015, Sarrafzadeh and Khaleghi 2017].

This fragmentation not only amplifies cognitive load but also disrupts workflow continuity, affecting productivity and collaborative coordination [Francese 2013, Hendl 2019, Madhusudhan 2016]. Rather than isolated technical inconveniences, they may indicate limitations in the integration of research infrastructures, reinforcing the need for more interoperable and user-centered software ecosystems [Lonergan 2017, Singh et al. 2022, Melles and Unsworth 2015, Francese 2013].

5.3. The Role of Research Software as Collaborative Systems

The results of this study reinforce the idea that the most widely used research software, such as Overleaf, Trello, and Figma, are designed to support essential collaborative activities, such as collaborative writing, task management, and the shared creation of artifacts [Barker et al. 2022, Hannay et al. 2009, Katz et al. 2019]. The recurrence of these tools indicates that collaboration is not a peripheral element, but rather a structuring element of research practice in Computer Science [Katz et al. 2019, Barker et al. 2022].

This finding is consistent with the quantitative findings, which show a predominance of collaborative tools among the most used software. The high frequency of platforms such as Overleaf and Trello reinforces the centrality of collaboration as a defining characteristic of research software use.

5.4. Institutional and Training Implications

The results suggest a possible gap between the central role that research software plays in academic work and the level of institutional support available for its effective use. Previous studies indicate that the adoption of reference and research management tools often occurs in an autonomous and self-directed manner, frequently without structured training or formal standardization policies [Speare 2018, Melles and Unsworth 2015, Francese 2013]. In this context, the absence of coordinated support mechanisms may contribute to heterogeneous work practices, partial use of available functionalities, and technical or usability challenges, as also discussed in the literature [Hendal 2019, Speare 2018].

Given this scenario, prior studies emphasize the importance of institutional initiatives aimed at technological training, including workshops, courses, and structured support for research software use [Sarrafzadeh and Khaleghi 2017, Speare 2018, Melles and Unsworth 2015]. Moreover, addressing barriers related to cost, usability, and technical limitations through institutional policies that prioritize accessible and interoperable tools may help mitigate fragmentation and support more integrated collaborative practices within academic environments [Hendal 2019, Speare 2018, Francese 2013].

These findings broader implications for the design of academic workflows and researcher training. The challenges related to usability, integration, and lack of training suggest that postgraduate programs would benefit from incorporating structured research software training.

6. Conclusions

Within the investigated sample, research software appears to act as a central component in Computer Science, being used across different phases of research. Tools such as Overleaf, Trello, and Jupyter not only support individual activities but also mediate organizational, coordination, and collaborative practices among graduate students, configuring themselves as true collaborative infrastructures in the academic context.

The results indicate, however, that this adoption appears to occur in a partially structured or uneven manner. The absence of formal training, the steep learning curve, technical problems, and the fragmentation between tools limit the full exploitation of their collaborative potential. These barriers impact not only individual productivity but also the effectiveness of collective work in research groups.

In summary, although widely used, research software still possesses untapped collaborative potential. Advancing the institutionalization of support for these tools, through training, standardization, and integration, is a strategic step towards strengthening scientific collaboration and the training of postgraduate researchers.

In response to the research question, the findings reveal a dual perspective on the use of research software, characterized by a tension between its role as an enabler of collaborative and productive scientific work and the practical constraints that hinder its full adoption. This balance between potential and limitation underscores the need for more integrated and supportive research environments.

As contributions, this work offers empirical evidence on how graduate students in Computer Science integrate research software into their academic practices and identifies

an adoption profile marked by the cross-functional use of these tools throughout the scientific workflow. It also provides practical support for institutions, faculty, and developers to strengthen collaborative practices mediated by software in graduate studies.

Among the study's limitations, the greater geographical concentration of participants in the Southeast region of Brazil and the exclusive focus on the field of Computer Science stand out, restricting the generalization of the findings. These limitations, however, point to directions for future research, such as comparative studies between areas of knowledge, longitudinal analyses on the evolution of the use of research software, and evaluations of formative interventions aimed at strengthening collaborative practices mediated by software.

By expanding the scope of investigation and examining diverse academic contexts, future studies can deepen the understanding of how research software shapes collaborative dynamics in postgraduate education. Such efforts will contribute not only to theoretical advancement in the field but also to the design of more effective institutional strategies for supporting digitally mediated scientific work.

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