Industry-Academy Collaboration in Agile Methodology: Preliminary Findings of a Systematic Literature Review

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Abstract: Collaborative Research between Industry and Academia (IAC) in Software Engineering (SE) is being applied and developed in practice. Collaborative practices help both environments, from academic and software industry perspectives. As a way of observing what is being developed in the SE, the objective of this article is to present an exploratory and empirical study of IAC practices in the scope of Agile Software Development (ASD), exploring and characterizing solutions and practices, the challenges found in the application of the IAC and the collaboration. A Systematic Literature Review (SLR) was carried out in five main academic databases, evaluating/analyzing 7143 articles, totalling 12 articles approved following the proposed criteria. As preliminary findings of the data analysis, 76 good practices and 37 challenges in carrying out the IAC were described. As well, practical models for the application of IAC were detailed.

1 INTRODUCTION

With a relevant quantity of practitioners, the Industry and Academic communities in the Software Engineering (SE) field are very large and diverse. Due to the importance of these two areas, the cooperation between them is very important for the enhancement of software development. Nevertheless, these two areas are usually disconnected (Glass, 2006; Garousi et al., 2016), with a low amount of researchers and practitioners collaborating with the other community. This practice of Industry-Academia Collaboration has a very important impact on SE, in which communities can identify each other's needs and develop cooperation strategies for those needs.

Agile methods usage is a consensus between practitioners at developing software and also very discussed in the academic community (Dingsøyr et al., 2012). Fostering this knowledge exchange can bring success for both communities, since there is a better understanding on the part of researchers of the needs of practitioners, ensuring competitiveness for organizations.

Over the past few years, there has been an increase in software development practices, requiring changes and refinements in the software development process. Several software development practices have been implemented and evaluated in the software industry (Boehm, 2006). Among the solutions, Agile Software Development (ASD) stands out as a useful, low-effort practice that presents a reduction in the failure rate in software development (Dyba and Dingsøyr, 2008a).

As academia and industry collaborate on projects that are applicable (Ven, 2007) (such as publishing, funding and academic practice vs. new technologies and industry project success), it is important to discover the challenges and propose practices to facilitate these collaborations.

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However, the number of collaborations between these communities is still considered low, resulting in gaps in the literature of studies involving IAC and Agile Software Development (ASD). In addition, industry and academia collaboration start from a problem that is not well defined, work in an environment of constant change and objectives are planned by iterative steps during project execution. The similarities discussed present good evidence for the observation of agile methodologies practices in a collaborative environment between industry and academia. The goal of this study is to carry out an Systematic Literature Review (SLR) of articles that present perspectives of collaboration between industry and academia in the Agile Software Development (ASD) context, focusing on identifying practices, challenges and models of IAC projects.

2 THEORETICAL REFERENCE

In this section, the main concepts necessary to understand the article were described, being about Agile Software Development (ASD) and Industry-Academy Collaboration (IAC).

2.1 Agile Software Development

In the article by Dyba and Dingsøyr (2008b), a systematic review of empirical studies on agile software development was carried out, with the goal of evaluating four themes: Introduction and adoption, human and social factors, perceptions about agile methods and comparative studies. From this review, 1996 papers were identified, of which 36 were identified as empirical studies and analysed. The review investigated the benefits, limitations and strengths of evidence of agile methods, through the analysis of the articles.

The global software industry requires continuous improvement to remain competitive and respond to rapid growth without losing software quality. In this process of reacting to these global software changes, agile methods represent a remarkable and widely used solution in today's industry (Kamei et al., 2017). The use of agile methods is a successful approach to software development, due to its flexibility and low maintenance effort, as well as the quality and speed of development (Chookittikul et al., 2011) (Santos et al., 2017).

2.2 Collaboration Industry-Academia

The integration and collaboration of academia with industry provides a unique learning environment, where researchers meet new industry insights in real-world environments, and the industry develops new technologies and solves problems within the company (Steglich et al., 2020; Garousi et al., 2017; Barbosa et al., 2020; Dallegrave et al., 2021).

One of the greatest challenges in the industry-academia collaboration is the adverse mentality of industry compared to academia, industry focuses on building and selling products and academia focuses on new knowledge and fundraising (Sandberg et al., 2011).

To investigate this process, Wohlin et al. (2012) conducted a survey with 48 researchers and 41 professionals, in Sweden and Australia, to observe and investigate the success factors of IAC practices in Software Engineering in general. Among these factors, we highlight: buy-in and support from the company's management; differences in goals among collaboration participants; and social skills are important and necessary, particularly in long-term collaboration.

The article by Santos et al. (2016) demonstrates the considerations about carrying out a research and development (R&D) project, about the applicability and experience of adopting agile practices in a collaborative project. In this project, the industry's need for shorter iterations, application of UML models and deliveries and team management, caused the project make organizational changes to agile practices, which was "crucial to managing expectations" of the industry.

3 RESEARCH METHODOLOGY

To conduct the systematic literature review (SLR), the well-established guidelines in software engineering defined by Kitchenham et al. (2007) and Petersen et al. (2015) were used, focusing on the research syntheses and the description of the challenges and practices applied in these researches. Figure 1 shows the scope of the research. The purpose of this study is to provide an insight into the challenges and practices carried out in the articles analysed, with a focus on agile practices. Thus, the following research questions were applied:

RQ1: What challenges to the application of IACs in ASD were raised?
RQ2: What are the proposed practices for improving IAC in the context of ASD?
RQ3: What types of IAC models have been proposed in the context of ASD?

To search for relevant studies, five main search engines are used, namely: ACM Digital Library, IEEE Explore, Science Direct, Scopus and Springer.

The final search string was based on two seminal works in the context of IAC (Garousi et al., 2016), and agile software development (Dingsøyr et al., 2012).

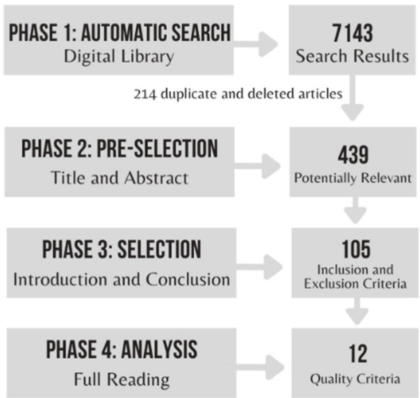

Figure 1: Methodology.

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(Industry OR Practice OR University OR
Academia OR Theory OR Collaboration OR
Relationship OR Relation) AND ("Agile
Development" OR "Agile Methodologies" OR
"Agile Software Development" OR "Agile
Methods" OR "Agile Projects" OR "Agile Project
Management" OR Scrum OR ScrumBan OR "Extreme
Programming" OR "Lean Software Development" OR
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In order to carry out the systematic literature review, the protocol was structured in four phases:

- **Phase 1 - Automatic Search:** consists of searching for articles in the databases;
- **Phase 2 - Pre-selection:** is pre-selection, which involves reading the titles and abstracts of the articles;
- **Phase 3 - Selection:** is carried out by applying the inclusion and exclusion criteria, reading and analyzing the introduction and conclusion of the articles; Based on the research questions, the criteria for inclusion (IC) and exclusion (EC) of articles were defined:

  IC1) Articles that answer the research questions;
  IC2) Articles that meet the quality criteria.
  EC1) Articles published from 2010 to 2021;
  EC2) Incomplete articles, secondary and tertiary studies, abstracts or slideshow;
  EC3) Articles not written in English;
  EC4) Articles that do not answer the research questions;
  EC5) Articles unavailable electronically;
  EC6) Duplicate articles; and
  EC7) Articles that do not meet the quality criteria.
- **Phase 4 - Analysis:** in the last stage, in order to recover relevant articles, some quality criteria (QC) were defined, following the guidelines of Dyba et al. (2007), namely:

  QC01) Is the theme of IAC addressed directly?
  QC02) Is there a case analysis in the company?
  QC03) Is it a real project with a real customer?
  QC04) Is the researcher inserted in the context, working in the company?
  QC05) Are there changes in the environment with the insertion of the researcher?
  QC06) Clearly answer the survey questions?

In this phase, the approved articles were read completely, leading to the set of primary studies of this review (Appendix).

4 RESULTS AND DISCUSSION

In this section, the preliminary findings of the data analysis are presented. In this way, the data are presented according to the research questions. The number of articles researched and the final results are shown in Table 1.

Table 1: Number of Articles Analyzed.

Database	Phase 1	Phase 2	Phase 3	Approved
IEEE	730	47	18	2
ACM	97	19	5	1
Science Direct	613	72	10	1
Scopus	3516	142	29	3
Springer	2187	159	43	5
Total	7143	439	105	12

From the primary studies found on the literature review, studies available in the appendix, the data coding and categorization process was started. Electronic spreadsheets were used for the construction simplified results, and for the construction of the categories, a qualitative analysis assistance software, Atlas TI, was used.

The analyzes and coding are built following the principles of Charmaz (2006), where Open and Axial coding were used to develop subcategories and categories in the data analysis.

Within these analyzes, 10 categories were created highlighting the challenges and impediments of collaborations (RQ1), 14 categories were created highlighting the best practices and patterns regarding the industry-academia collaboration process (RQ2), in addition to presenting collaboration models for the practice of IAC (RQ3).

In the link (shorturl.at/uEMV7) it is possible to observe the research protocols, the approved articles, the demographic data and the list of categories and subcategories of each of the research questions.

4.1 RQ1: What Challenges and Impediments to the Application of IACs in ASD Were Raised by Newspapers?

This question analyzes the challenges and impediments found in the analyzed articles. As result, 10 categories and 37 sub-categories (labelled by CI) were highlighted. Thus, the main categories are represented in the Table 2:

Table 2: Representation of the categories of Challenges in the application of IAC.

C01: Incompatibility between industry and academia
C02: Research Method
C03: Lack of Training, Experience and Skills
C04: Lack of interest or Low Commitment
C05: Problems related to Communication
C06: Human and Organizational Factors
C07: Issues related to Agile Practices
C08: Issues related to Management
C09: Resource-related Issues
C10: Contractual and Privacy Concern

Category 01 represents the incompatibility between industry and academia, where they represent the contrasts of reality on both sides. This category describes the different perceptions of the collaboration fields, where they demonstrate different interests and objectives (CI06), perceptions of challenges (CI15) of solutions and of different results (CI25). In addition, they represent differences between the industry and academia schedule (CI04) and difficulty in synchronizing schedules (CI03). This category is represented by 10 subcategories.

Category 03 is represented by the lack of training, experience and skills of project employees. Thus, the lack of skill and experience in Software Engineering (CI21) and Agile (CI20) are factors that hinder these collaborations, as well as the difficulties in collaborating with the researchers' solutions (CI16), where training in both contexts are necessary (CI20 and CI21). This category is made up of only 3 sub-categories.

The lack of proper communication between the members of a collaboration is one of the main challenges to leverage collaborations. In Category 05, 3 subcategories are presented that represent this knowledge. The insertion and availability of the researcher at the collaboration site (CI12) and the communication gaps between communities (CI26) are challenges for the practice of collaboration. Another form of communication challenge is concealment or difficulty in obtaining information from the team (CI37).

Agile practices, in Category 07, is the main point of the research project, so agile practices also present difficulties in applications in collaborative projects. The difficulties involve the difficulty of following the iterations (CI09), the interruption of the iterations (CI10) and short sprints (CI11) of the project. In addition, some projects are resistant to changes from traditional approaches to agile (CI33). This category is made up of only 3 subcategories.

In this section, 4/10 categories were presented that represent the challenges and impediments for a collaborative project, in addition to the representations of the subcategories. The categories presented represent the highest degrees of "groundedness", the other categories and subcategories are exposed in the link (available in the results section).

4.2 RQ2: What Are the Proposed Practices for Improving the IAC in the Context of Agile Software Development (ASD)?

This question analyzes the good practices that were developed and represented in the analyzed articles. In total, 14 categories and 76 subcategories (labelled by GP) of practices were constructed in the development of an IAC. In Table 3, it is possible to observe the categories constructed.

In Category 01 (Knowledge Management), good knowledge management practices of the collaborating teams are described, such as communication skills, training and social and research skills. Some practices that were described in this category are: holding seminars and workshops (GP31), conducting training (GP54), promoting satisfaction with learning (GP24) and developing social and management skills (GP42). In addition to these four practices, four more practices were also developed, summarizing 8 subcategories.

Category 02 (Project Management and Engagement Assurance) focuses on the collaboration and involvement of project participants. Thus, it is necessary to meet the needs of the industry (GP35), ensuring the involvement of the industry (GP11), the transfer of knowledge (GP16) between employees and the development and encouragement of the industry (GP03). This category is represented by 8 subcategories.

Table 3: Representation of good practice categories for collaboration.

C01: Knowledge management (communication, training and skills)
C02: Ensuring engagement and project management
C03: Considers industry needs, challenges, goals and problems
C04: Ensuring benefits for the industry and solving problems
C05: Maintaining relationships and understanding
C06: Software Agility
C07: Teamwork
C08: Manage Risks and Limitations
C09: Researcher Available and Accessible
C10: Manage Financing / Recruitment / Partnership and Hiring
C11: Measurement and Evaluation
C12: Support Tools Search
C13: Test / Pilot Solutions
C14: Provide tool support for solutions

In Category 03, categories are represented that consider the needs, challenges, goals and problems in the industry, whether in the construction of the research project or in the execution of the project. Thus, problems based on real facts (GP43) and the involvement of professionals in the construction of the problem (GP12) are important factors in collaborations. But also, the research must meet the needs of the industry, as well as that of the researcher (GP18). This category is represented by 8 subcategories.

Aspects related to relationships, social skills and collaborative behavior are represented by Category 05, which presents 8 subcategories on these practices. The socialization of the proposal in the organization (GP02), the close contact of the researcher in the place of collaborative practice (GP05) and the establishment of trust and satisfaction (GP20) are fundamental practices in this category. In addition to these, planning meetings, whether daily or periodic, should be pursued (GP06).

The agile aspects is the central point of the research, where the observation and analysis of these practices are very suitable for the context of IAC. In Category GP06, the contexts of Software Agility aimed at collaborations were presented. This category is represented by 15 subcategories.

The inclusion of agile practices in collaborative projects (GP32) act in very positive ways, such as managing expectations Santos et al. (2016) and converting large projects into smaller projects (GP30). In addition, the use of short iterations, short cycles and sprints (GP26) are one of the main factors in the insertion of agile methodologies. The Sprint Retrospective (GP62), Planning Ceremony, Sprint Review (GP40), Daily Meeting and/or Planning Meeting (GP07) and Daily Standup (GP69) practices are well applied in the contexts studied.

Agile skills such as Spike Solution (GP56), Pair Programming (GP57), Planning Poker (GP61) and User Story (GP21) were also reported in the development of collaborations, these skills being related to team training, project execution, competence levelling (described in Category 01, GP59) or in the construction of the research/development proposal.

In this section, 5/14 categories were presented, with the archiving of some subcategories that represent the knowledge of the respective category, the categories that present higher degrees of "groundedness" were described. The other categories and subcategories are presented in the link (available at the beginning of the results).

4.3 RQ3: What Types of IAC Models Have Been Proposed for the Context of ASD?

Studies such as those by Garousi et al. (2016) and Marijan and Gotlieb (2021) describe the application of case studies and action research and present collaboration models for IAC practices, such as the "Certus Model" and the "Spiral Model". Collaboration models determine the practical structure and roles of project participants (Marijan and Gotlieb, 2021). In the analysis, five models of collaboration were described for the practice of IAC in agile contexts.

The research paper authored by Munch et al. (2013), the authors provide a **"technology transfer model"** that is directly related to the construction of a Minimum Viable Product (MVP) in academia and, after the construction, the transfer to the domain of industry. Among the steps used to apply the model are: **i)** Identify problems on industry by a case study; **ii)** Formulate a solution for the problem, with the industry cooperation; **iii)** Make validations of these solutions; and **iv)** disclose the step by step for implementation in industry.

In Choma et al. (2015a) is presented the **Cooperative Method Development (CMD)** models, which has as main characteristics the action research principles, with an approach more qualitative and combining with problem-oriented methods. The CMD application cycles are: **i)** Understanding the practice; **ii)** Deliberate improvements; And **iii)** Implement and observe improvements.

Making a junction with CMD with Design Science Research (DSR) practices for the conduction of a collaboration, the article authored by Choma et al. (2015b) presents the methodology **"SoftCoDer"** based on this junction of principles. In the work of Choma et al. (2016), the approach "SoftCoDer UserX Story: Incorporating UX Aspects" is presented, which brings the foundation of the CMD, with guidelines from the DSR, such as: "design artifacts of value based on both real need of industry (relevance) and scientific knowledge (rigor of research)".

Also using the action research methodologies, the paper authored by Babb et al. (2014) presents the **Dialogical Action Research (DAR)**, which is an emerging and engaged approach in both research and practice, where it is designed to promote an understanding of applications to practical phenomena. As a form of collaboration, the DAR presents "a researcher/practitioner partnership that allows for a reflective dialog to explore and shape change in an organization and also specify learning for a scientific community".

In the study authored by Sandberg et al. (2011) is presented the concept of **Collaborative Practice Research (CPR)**, where the concepts of practitioners ("insiders") and researchers ("outsiders") are applied who work in close collaboration, where they take advantage of bringing their knowledge in identification, analysis and interpretation together in the project.

5 DISCUSSION AND VALIDITY

In this section, discussions about the results found are presented, as well as threats to the validity of the study.

5.1 Discussion

The research is based on describing factors that influence the practice of collaborations between industry and academia, where through the factors presented in the research, it is possible to enhance new collaborations and reduce potential failures.

One of the main practices, based on the number of citations in the analysis, was the insertion of the researcher in the industrial context, carrying out this exchange of knowledge. The researcher in the inserted context is free to collect evidence and experiences, feelings and difficulties of the participants, to build insights, hypotheses and solutions for the environment. All these elements should be discussed openly between the collaborating parties, which is good practice in these collaborations.

For a better interposition of researchers in the context of the industry and a successful collaboration between the communities, an excellent and frequent practice in the analysis of the data is the accomplishment of training and leveling of knowledge between practitioners and researchers. However, challenges such as lack of time and incompatibility of agenda for building new knowledge can be found in conducting collaboration.

Having as a reference the incompatibilities of schedules, interruptions of iterations and time windows for the research, the agile practices present a good way out for these problems. Agile practices such as short iterations, sprint review and planning meeting react very well to changes in the environment.

The models described in RQ3 are important ways on how to execute an IAC in some context. From these models, it is possible to repress risks to the performed researches. As presented in RQ3, there are several models that propose the execution of collaborative practices, such as the certain model (Marijan and Gotlieb, 2021), spiral model (Rombach and Achatz, 2007), collaborative models aimed at agile research (Sandberg et al., 2011; Sandberg and Crnkovic, 2017) and, the one that has been gaining a lot of space in the research, the technology transfer model (Gorschek et al., 2006; Mikkonen et al., 2017).

5.2 Threats to Validity

This section discusses some threats to research validity, namely:

- Research carried out by two researchers, where a third and a fourth researcher acted as support and data validation;
- Searches performed in the five main automatic databases, but not applied to searches in manual databases.
- Each data repository has its own search processes, so it was necessary to adapt the string in each of the repositories;
- The quality ratings of the articles were based on the "five levels of closeness" proposed by Wholin (2013) and described by Garousi et al. (2019). In this way, stricter criteria were placed as defined by the authors on IAC.

6 CONCLUSIONS

Collaborations between industry, academia and government have the power to leverage both fields, academically and industrially, in a very positive way. The inclusion of research collaborations tends to help in the formation of more qualified researchers and to make the industries more adequate to the technologies and to enhance the processes.

The objective of the research is to carry out an exploratory review of articles that present a perspective of collaboration between industry and academia (IAC), in a software agility perspective. To perform these analyses, a Systematic Literature Review (SLR) was conducted on five main search engines.

As preliminary findings of the systematic review, and with the performance of a qualitative analysis on the articles evaluated, 10 categories and 37 subcategories were built on the challenges and impediments of the execution of IAC, and 14 categories and 76 subcategories that express the good practices on the execution of collaborations between industry and academia.

In addition, 5 models were exposed for carrying out an IAC. Agile practices in collaborative projects (IAC) are very adherent due to the need to demonstrate fast and qualified results, this is widely applicable using short iterations, quick meetings and short sprints.

As future perspectives, our next step is to validate the results with professionals in the field and design an ontology model relating the challenges with the good practices in the context of the IAC. Therefore, this conceptual model may serve to organize and structure the domain, through which professionals can perform reasoning task in order to infer a set of practices to be introduced within a specific IAC project based on the identified challenges.

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APPENDIX – INCLUDED STUDIES

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[S4] Choma et al. (2015). Communication of Design Decisions and Usability Issues: A Protocol Based on Personas and Nielsen's Heuristics. doi: 10.1007/978-3-319-20901-2 15 **[ID07]**

[S5] Santos et al. (2016). Using Scrum Together with UML Models: A Collaborative University-Industry RD Software Project. doi: 10.1007/978-3-319-42089-9 34 **[ID09]**

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[S8] Choma et al. (2015). Towards an Approach Matching CMD and DSR to Improve the Academia-Industry Software Development Partnership: A Case of Agile and UX Integration. doi: 10.1109/sbes.2015.18 **[ID12]**

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