Introducing Agile Methods in Undergraduate Curricula, a Systematic Mapping Study

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Abstract. Agile approaches to Software Engineering are widely used nowadays in industry and have also reached academic environments, with universities all around the world including agile related content in their programs. There are no formal studies about the current situation of Agile Software Development in Argentinian Universities. A systematic mapping study was conducted to understand the state of agile in undergraduate curricula. Results show that Agile Software Development is part of the Information Technology and Computer Science Programs and that Scrum is the most popular agile method in that context. There is little information regarding the teaching strategy used but a learning-by-doing approach is used in many cases.

Keywords: Agile, Software Engineering, Education

1   Introduction

Agile Methods have their origin in the late 90' but their foundational year was 2001 when the Agile Manifesto [1] was published. Since then the popularity of Agile has been in constant growth. A study published by Forrester [2] in 2010 considered Agile Methods as mainstream. Companies, practitioners, professors and researchers have embrace Agile Software Development. Classical textbooks on Software Engineering like the books by Pressman [3] and Sommerville [4] have included Agile topics several editions ago; and the ACM has included agile in its curricula recommendations for Software Engineering and Information Technology [5].

In Argentina, many software companies have adopted Agile methods too [6], and there are reported experiences of teaching agile in university courses [8, 9]. There is also a proposal by Reingart and Dominguez [10] for a Free Software Diploma Program that explicitly includes Agile Methods. Still, for higher education, the regulations and guidance for the accreditation of Information Technology and Computer Science [3] programs does not mention Agile methods at all [7].

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[3] In the context of this article the term Information Technology and Computer Science programs is used to refer to the programs covered by Resolution 786/2009 [7]

When talking about Agile and Education we distinguish two clearly different topics: teaching Agile Software Development and using Agile techniques to teach any subject matter even beyond software development. This work is focused on the first topic: teaching Agile Software Development.

There are some studies reporting evolution and/or state of the art in Agile Software Development education in particular regions worldwide which is something similar to our goal. A study similar to ours was carried out in Thailand by Chookittikul et al [11]. The researchers performed interviews in several leading universities in Thailand to understand how agile methods were incorporated into computer science curricula. A broad study on Agile evolution in Brazil was conducted by Melo et. al. [12] which covered industry, education and research.

At the time of this writing, there are no formal studies of the current situation of Agile Software Development teaching in the Computer Science and Technology programs in Argentina. The goal of this study[4] is to understand the state of Agile Software Development teaching, to identify further research opportunities.

Our research questions are:

- RQ1: Are Agile methods part of the Information Technology and Computer Science programs in Argentina?
- RQ2: What is the Agile method most commonly taught?
- RQ3: Is there any particular teaching strategy used to teach Agile methods?

The rest of this article is organized as follows: Section 2 explains the details of our review method, Section 3 presents our results and findings, Section 4 discusses specific issues of interest in our findings, Section 5 presents the threats to validity and finally Section 6 presents conclusions and future lines of work.

2   Review Method

This work was conducted following the guidelines provided by Kitchenham [18] and Kuhrmann [17] for Systematic Mappings Studies.

2.1   Data Sources and Search Strategy

In Argentina there are seven national conferences in the area of Information Technology and Computer Science:

- CACIC: Congreso Argentino de Ciencias de la Computación.
- JAIIO: Jornadas Argentinas de Informática e Investigación Operativa.
- TEyET: Congreso Nacional de Tecnología en Educación y Educación en Tecnología.
- WICC: Worshop de Investigadores en Ciencias de la Computación.

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[4] This study is part of the final specialization assignment in the context of the Specialization Degree in IT Applied to Education Program of the Faculty of Informatics at Universidad Nacional de La Plata

– CONAIISI: Congreso Nacional de Ingeniería Informática - Sistemas de Información.
– CACIDI: Congreso Argentino de Ciencias de la Informática y Desarrollos de Investicación.
– ARGECON: Congreso Bienal de IEEE Argentina.

In addition to these conferences there are some relevant Argentinian journals in the same area:

– JCS&T: Journal of Computer Science & Technology
– Revista TEYET: Revista Iberoamericana de Tecnología en Educación y Educación en Tecnología
– EJS: Electronic Journal of SADIO

To search on all these sources (journals and conferences) different search engines were used because there was no unique search engine covering them all.

The search string was composed of two parts connected with AND:

1. agile OR ágil OR Scrum
2. educación OR education OR enseñanza OR teaching

In the first part of the search string we decided to explicitly include Scrum because we consider that it has such great popularity in industry that sometimes practitioners refer to Scrum as a synonym of Agile [13] even when this is not correct because Scrum is just one of the agile methods.

So the final search string was:

(1) AND (2)

A third part might be added to the search string to restrict articles to Argentina as that is the scope of this work, but we assumed that authors might not mention the country where the research work is performed but only their institution. So we decided to not include "Argentina" in the search string.

When trying to use this search string in the different search engines several restrictions were found. Because of that this "conceptual" search string had to be adjusted to the limitation of each search engine which in some cases implied the execution of several partial searches.

To search on the proceedings of CACIC, JAIIO, TEYET and WICC, we used SEDICI[14], the institutional repository of the Universidad Nacional de La Plata that beyond items authored by its members it also stores items generated by other institutions like Red UNCI (the institution that organizes CACIC, TEYET and WICC) and SADIO (the institution that organices JAIIO). It is important to mention that SEDICI has JAIIO proceedings since 2013, so JAIIO publications in JAIIO proceedings prior to 2013 are not covered in this study. SEDICI does not support connectors in the search string but it offers a feature to filter search results by keywords and subject. So when using SEDICI we performed several partial searches and used the keywords and subject filters.

To search on CACIDI and ARGENCON proceedings IEEE Xplore [16] was used because these two conferences are IEEE Conferences. In these cases the

search string was extended to include the name of the corresponding conference (CACIDI or ARGENCON in each case).

To search for international publications we used Scopus [15] which covers most relevant conferences and journals in the area of education and software engineering like the International Conference in Software Engineering, Computer and Education Journal and Transactions on Education Journal, etc. This particular search engine allowed us to add a restriction to the search string to limit articles by affiliation country, so this way we limited the search to Argentina.

To search on CONAIISI proceedings a manual procedure was used because these proceedings are not covered by any search engine. At the same time the different editions of this conference have taken different approaches to publishing their proceedings. Editions 2013, 2016 and 2018 published their proceedings in their websites offering a link for each published paper. At the same time editions 2014 and 2017 offered a unique link to a single PDF file containing all the articles. Finally, proceedings of edition 2015 are not available online so they were not covered in this study.

Finally we also performed a manual search on the available issues of the Electronic Journal of SADIO (EJS).

Table 1 summarizes the search engine used to search each source.

Table 1. Search engines and sources.

Search Engine	Source
SEDICI	CACIC, WICC, JAIIO, JJCS&T, TEYET (proceedings and journal)
IEEE Explore	CACIDI, ARGENCON
Scopus	International publications
Manual Search	CONAIISI, EJS

2.2 Inclusion and exclusion criteria

Studies eligible for inclusion in the review were those that describe or mention the teaching or usage of agile software development within undergraduate programs in the area of Information Technology and Computer Science programs in Argentina.

Studies were excluded if their focus was the use of agile techniques to teach something other than software development. This exclusion criteria in important because there is an increasing trend regarding using agile techniques beyond software development. Other excluded studies were those describing a proposal to teach agile but without an associated validation experience. Finally we also discarded those studies that mentioned the use of agile to develop education software.

2.3 Review Process

The review process was composed of three stages. In the first stage of the process we collected articles by performing searches in the different sources using the search string. We managed the results provided by each search engine in separate spreadsheets, this was because each search engine had different export capabilities. The result of this first stage gave us 582 items.

In the second stage we filtered items by reading the title and abstract of each item, and applying the inclusion and exclusion criteria. We completed this stage with 40 items that we stored in an unified spreadsheet. Having all items in the same spreadsheet would allow us to eliminate duplicates in the next step.

In the third and final stage we reviewed the items in detail by reading the full articles and performing the data extraction. In this third stage we eliminated duplicated items. While working on this stage we found a special kind of publication in JAIIO proceedings called "Oral Communications". This kind of publication was not an original work but a summary of work that had been previously published in another conference. Based on this we considered oral communications as duplicates.

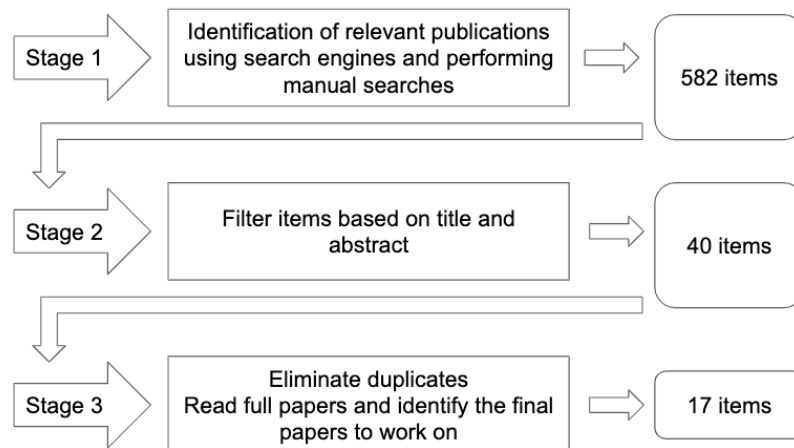The whole review process is summarized in figure 1.

Fig. 1. Stages of the review process

2.4 Quality assessment

Each of the 40 studies that remained after stage 2 was assessed independently by two authors, according to the inclusion/exclusion criteria.

3   Results

We started to work on this study on May 2019 and the different searches where executed on June 2019. We identified 17 articles[5] that met the inclusion/exclusion criteria about teaching agile software development. These articles are listed on table 3. The selected articles belong to nine different institutions as shown in table 2. Most of these institutions (eight out of nine) are public universities.

Table 2. Institutions with publications about teaching agile.

Institution	Count of publications
UNICEN	8
UNLAM	2
UTN Cordoba	1
U. de la Cuenca del Plata	1
UN de Salta	1
UN del Nordeste	1
UN de La Plata	1
UN de Rio Cuarto	1
UN de Tres de Febrero	1

In addition to selected articles we found another set of articles that did not match the selection criteria for different reasons but we think it is interesting to mention them: a) an article proposing a pre-degree program that included agile methods and b) two articles describing extra-curricular courses about Agile Software Development.

Regarding the specific programs mentioned in the articles we found 14 articles related to Engineering programs, two articles related to Bachelor programs and one article related to a Systems Analyst program.

Regarding the publication year, the first publication dates back to 2012. Table 4 shows the count of publications per year.

Regarding Agile Methods, most of the articles (11) mention Scrum while some others (3) mention Extreme Programming. There is one article that mentions Scrum and Extreme Programming. Two of the articles do not mention any agile method at all. This popularity of Scrum is aligned with what is observed in industry [20].

Most of the papers do not mention any agile practices beyond those that are part of Scrum. It is reasonable to think that those teaching Scrum are also teaching its practices. Beyond Scrum and its practices there are two articles that explicitly mention three practices each. Table 5 shows the details on practices mentioned in articles.

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[5] Full   references   of   these   articles   are   available   in   the   appendix
https://doi.org/10.6084/m9.figshare.9178097.v1

Table 3. List of selected papers

Id	Title	Source
1	La Evolucion de las Catedras para Influir en los Know-mads y Formar al Trabajador de la Industria 4.0	CONAIISI 2017
2	Experiencia sobre desarrollo con Genexus siguiendo practicas agiles	TEYET 2016
3	Mejora continua aplicada en la ensenanza de la Ingenieria del Software	TEYET 2015
4	Implementacion practica del agilismo en proyecto de Ingenieria de Software	JAIIO 2016
5	Experiences in software engineering education: Using scrum, agile coaching, and virtual reality	Book Chapter
6	Propuesta para documentar trabajos finales utilizando metodologias agiles	TEYET 2014
7	Are learning styles useful indicators to discover how students use Scrum for the first time?	Computer in Human Behaviour Journal
8	El rol del estilo de aprendizaje en la ense´ anza de practicas de Scrum: un enfoque estadistico	JAIIO 2013
9	Measuring the Impact of Agile Coaching on Students' Performance	IEEE Transactions on Education
10	Supporting assessment of practices in software engineering courses	IEEE Latin America Transactions
11	Teaching scrum to software engineering students with virtual reality support	ADNTIIC 2011
12	Towards better Scrum learning using learning styles	ADNTIIC 2011
13	Virtual Scrum: A teaching aid to introduce undergraduate software engineering students to Scrum	Computer Applications in Engineering Education
14	Mejoras en el proceso de ensenanza / aprendizaje de la programacion utilizando metodologias de la industria del software	CONAIISI 2013
15	Metodologias activas y correccion por rubricas en el proceso de ensenanza / aprendizaje de programacion	CONAIISI 2014
16	A flipped classroom experience teaching software engineering	SECM 2017
17	Como Pueden Scrum y las TICs Mejorar el Aprendizaje Colaborativo en el ambito Universitario?	CONAIISI 2017

Regarding the teaching strategy about a third of the articles does not mention anything. Those that make an explicit mention regarding this concern are:

– Article 1 and 15 mention a problem-based learning approach.
– Article 16 mentions a flipped-classroom approach.
– Articles 5, 11 and 13 mention the use of virtual reality (these articles belong to the same group of authors).
– Articles 7, 8 and 12 mention the Felder-Silverman learning styles.
– Article 17 mentions a collaborative learning approach.

In many cases students are required to develop a project in the context of a software engineering course using an agile approach which may represent a "learning by doing" strategy.

Table 4. Publication about teaching agile by year.

Year	Count of publications
2012	1
2013	1
2014	5
2015	3
2016	5
2017	4
2018	1

Table 5. Practices mentioned in articles beyond Scrum.

Practice	Articles id
Self-Organization	2, 9
Definition of Done	2
Automated testing	9
Continuous Integration	9
Release Planning	12
Planning Poker	12
Pair-Programming	14, 15
Test-Driven Development	16
Story Mapping	16
Retrospectives	16

4   Discussion

We found 17 articles on teaching Agile Software Development in the context of Information Technology and Computer Science programs in Argentina. Those

articles belong to nine different institutions but according to Fundación Sadosky [19] there are 43 different university level institutions in Argentina offering degree programs in the Information Technology and Computer Science area. Beyond this, the authors personally know several professors (i.e. in UBA, UTB-FRBA and UCA) that are teaching Agile Software Development but that have never published any articles about this. So it might be assumed that Agile Software Development is present in the Argentinian universities to a higher degree than was found in this research study.

5   Threats to validity

The ability to draw general conclusions from this research is limited by the fact that only published experiences are being surveyed, as we have mentioned. This research carefully considered actual curricula, not planned approaches, to avoid misreading situations were the intent was not carried out.

The conclusions of this work might also be affected by the fact that some relevant articles might have been missed for 2 different reasons:

- Part of the search was performed manually, so like any manual task it is error prone.
- JAIIO publications prior to 2013 are not available online in a digital format, so it was not possible to cover them.

6   Conclusions

Evidence shows that Agile Software Development is part of the Information Technology and Computer Science Programs in nine Argentinean universities, this answers our first research question.

Regarding our second research question, Scrum is the most common method taught (it is mentioned in 12 out of 17 publications). Some reports do not mention any method but describe specific practices.

Regarding the third research question, there is little information about the teaching strategy and several papers do not mention it at all. Among the articles that do mention elements related to this there is no single preferred approach but a learning-by-doing strategy is used in many cases.

The results and findings presented in this article open several possible lines of work. In the context of the Specialization Degree assignment our next step will be performing interviews with professors of software development courses in order to have a deeper understanding of the teaching strategy. The goal will be to perform enough interviews to obtain representative results to describe the state of agile education in Argentina. Beyond our next steps, it might also be interesting to assess the impact that agile education experiences have on practitioners if and when they join the software development industry.

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