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A Systematic Mapping Study of ISO/IEC 29110 and Software Engineering Education

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Abstract. This article presents a study of the publications made on the ISO/IEC 29110 standard in the university context, especially from the perspective of software engineering education. ISO 29110 is a life cycle profiles for very small entities on systems and software engineering standard, published in many parts. ISO 29110, since its publication in 2011 and its continuous evolution to these days, is the subject of study in different contexts, with education being a relevant axis. Considering, that software engineering education has implications in the software industry in emerging countries, it is necessary to identify and consolidate the work done in this context. In this study, the main research question was what researches have been done at ISO 29110 in the training of software engineers? To answer this question, a systematic mapping study (SMS) was performed. In the SMS, 241 articles were obtained with search string and 17 of them became as primary study after a process selection. Based on these studies, it was possible to determine that the software engineering Basic profile of ISO 29110 and its processes (Project Management and Software Implementation) have been the most studied. Besides, it was identified that project-oriented learning and gamification techniques have been the most used ISO 29110 learning strategies in the training of future software industry professionals.

Keywords: ISO/IEC 29110; systems and software engineering; life cycle profiles; software engineering education

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Систематический обзор литературы по стандарту ISO/IEC 29110 и образованию в области программной инженерии

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Аннотация. В этой статье представлено исследование публикаций, посвященных стандарту ISO/IEC 29110 в университетском контексте, особенно с точки зрения образования в области разработки программного обеспечения. ISO 29110 состоит из профилей жизненного цикла разработки систем и программного обеспечения, ориентированных на использование в очень мелких предприятиях, и опубликован во многих частях. Стандарт ISO 29110, с момента его публикации в 2011 году и за время его непрерывного развития по сей день, является предметом изучения в различных контекстах, причем важным элементом является образование. Учитывая, что образование в области разработки программного обеспечения имеет значение для индустрии программного обеспечения в развивающихся странах, необходимо определить и консолидировать работу, проделанную в этом контексте. В этом исследовании основным исследовательским вопросом было то, какие исследования были проведены в соответствии с ISO 29110 при подготовке инженеров-программистов? Чтобы ответить на этот вопрос, было проведено систематическое исследование литературных источников. В ходе работы с помощью поисковой строки была получена 241 статья, и после отбора 17 из них стали основными для дальнейшего исследования. Основываясь на полученных результатах, можно судить, что наиболее изученными являются базовый профиль разработки программного обеспечения и его процессы управления проектами и внедрения программного обеспечения стандарта ISO 29110. Кроме того, было выявлено, что при подготовке будущих специалистов индустрии программного обеспечения наиболее часто используемыми стратегиями обучения по стандарту ISO 29110 были проектно-ориентированное обучение и методы геймификации.

Ключевые слова: ISO/IEC 29110; системная и программная инженерия; профили жизненного цикла; обучение разработчиков программного обеспечения

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1. Introduction

The ISO/IEC 29110 is a set of standards developed for very small entities (VSEs) in the IT field with up to 25 people [1]. In 2011, the publication of the software engineering Basic profile of ISO 29110 begins [2] and 2014 for systems engineering [3]. In [3], it is noted that other documents, e.g. Agile, are under development for VSEs. Also, according to [4], the research related to ISO 29110, has been growing all these years.

In 2012, in a United Nations report [5], is pointed out that the software industry in emerging countries is considered strategic to ensure adequate growth of their economies. Furthermore, in [5] two important issues are pointed out as a need for the software industry in emerging countries: (i) the need to apply appropriate (quality) process models, and (ii) the education of software industry professionals in these emerging countries. These two needs find an initial response in the 29110 standards [1] and a potential answer in the findings of [4], where education is identified as a focus of research interest.

Studies on software process models, in the training of professionals, have been carried out in other cases, such as: MoProSoft [6], CMMI [7] and ISO/IEC 12207 [8], [9]. In the Systematic Mapping Study (SMS) [4] on 179 selected studies, up to 2018, it was identified that 44 of them are classified in the context of education. However, as the authors point out [4], they consider various facets of education, including university and industry contexts.

Taking into account the work of [4], and considering that other standards are developed for 29110 such as Agile and DevOps [10], and the need expressed in [5], it is expected that research on ISO 29110 will continue in the university context. This research interest is justified by the benefit of training software engineering students [9], who can then apply it in their professional life [11], [12], [5], [13] in a company or in a software-based startup [14], [15].

On the other hand, software engineering worldwide, from its origins in 1968 [16], [17], through its consolidation as a discipline by means of a curriculum guide in 2004 [18], [19], has changed significantly in all those years [20]. Nowadays, exists new challenges for software engineering, both at the technical level (emerging technologies) and at the level of business models within the software industry itself [5]. Also, the software industry is mostly made up, worldwide, of micro, small and medium-sized companies [5], [21]; and in emerging countries, they have other characteristics and needs.

The objective of this study is to identify, detail what is researched about ISO 29110 in software engineering professional training. For this purpose, we carried out a Systematic Mapping Study (SMS). The article is organized as follows: in Section II, some concepts and related works are described; in Section III, the SMS is developed; in Section IV, the results are analyzed; and, in Section V, the conclusions are presented.

2. Background and Related Work

This section briefly introduces the concepts of ISO 29110, the discipline of software engineering and related work.

2.1 ISO/IEC 29110

The International Organization for Standardization - ISO, concerned about the global software industry, initiates the development and publication of a family of standards that has been named ISO/IEC 29110 and known as VSE (very small entities) project [3]. ISO 29110 has developed, among others, a process model for organizations that develop software [3]. This standard is based on MoProSoft (developed for the Mexican software industry [3], [22]) and some contributions from participants of the Competisoft Project. According to [23], ISO 29110 represents an aid to improve development processes in the software life cycle.

According to Part 1 of ISO 29110 [1], the group of standards is organized into an overview document, a group of profiles documents with their assessments and certifications, and a group of implementation guidelines. A profile extracts and tailors the elements of a standard to meet specific needs [2]. Profiles published of software engineering [10] are 4 profiles: Part 5-1-1:2012 Entry profile, Part 5-1-2:2011 Basic profile, Part 5-1-3:2017 Intermediate profile and Part 5-1-4:2018 Advance profile.

2.2 Software Engineering Discipline

Software Engineering discipline evolves in the context of other disciplines related to computing. Therefore, the Computing Curricula of 2001 or CC2001 [19], constitutes a first milestone since it starts a process of identification of 5 domains of its own and initial overlaps between these disciplines are identified. In 2016, the Guide was updated and published under the name CC2020 or Computing Curricula 2020, introducing the competency-based approach [27] and 7 new sub-disciplines [28]. In 2014, the SWEBOK v3 (Software Engineering Body of Knowledge version 3)

guide is published [30]. In SWEBOK V.3, ISO/IEC 29110 is included [30]. Finally, two important aspects of software engineering education are: (i) the level of introduction of software engineering programs in universities worldwide; which is still incipient [32]; and, (ii) the amount of software engineering contents (techniques and practices) incorporated in university programs that train software industry professionals is not enough [13].

2.3 Related Work

As related works we identified: (i) an SMS on ISO 29110 conducted, in [4] classifying the results according to emerging axes of the study, noting that the topic of education is one of the most researched; (ii) a Report for the 10th anniversary of ISO 29110 in [11], which presents a compilation of ISO 29110 implementation experiences in different contexts (industry and academic) and from various countries; and (iii) an SMS on Software Engineering Education (SEE) in [33], that points out, among other things, a change towards new trends in software engineering: global software development and lean software startup; in academic and industry contexts; (iv) a systematic mapping study was carried out on the application of serious games in the teaching of the software development life cycle in [34], concluding that serious games are a motivational tool to increase the knowledge and learning of students.

3. Research Method

For this research, a SMS was carried out taking as the main reference point Petersen's proposal [37].

3.1 Research Questions

The achievement of the objective is translated into the following research questions (RQ):

RQ1. How has the number of ISO 29110 publications in university education evolved over time?

RQ2. What is the studies distribution by type of article in relation to ISO 29110 in education?

RQ3. What ISO 29110 processes have been addressed in university education?

RQ4. What kind of pedagogical techniques or activities have been used for learning ISO 29110 in university education?

RQ5. What academic purpose is served by studies of ISO 29110 in the university context?

3.2 Research Protocol

Based on Petersen's recommendation [37], the Population and Intervention scheme (P AND I) was used to define the search string. The population is “ISO/IEC 29110”, and intervention is “education”. From the main terms and alternate terms, the search string was established as: *("ISO/IEC 29110" OR "ISO 29110") AND ("education" OR "program" OR "university" OR "training" OR "undergraduate" OR "postgraduate" OR "student" OR "academic" OR "course" OR "doctor" OR "master")*. This search string has applied to the follow digital database: Web of Science, IEEE Xplore, ACM DL, ProQuest, Scopus, and Springer. Also, as ISO/IEC 29110 is based on MoProSoft, a Spanish search string *("ISO/IEC 29110" OR "ISO 29110") AND ("educación" OR "programa" OR "universidad" OR "entrenamiento" OR "pregrado" OR "postgrado" OR "estudiante" OR "academico" OR "curso" OR "doctorado" OR "maestria")* was applied to Scielo digital database. It is important to note that papers in Scielo have a title and abstract write both in Spanish and Portuguese.

The inclusion (IC#) and exclusion (EC#) criteria established were:

IC1. Refers to ISO 29110 at the university context (or similar).

IC2. Written in English, Spanish or Portuguese.

EC1. Duplicates.

EC2. Refers to ISO 29110 in a non-university environment, such as companies or government agencies.

EC3. Content does not present information about the research questions.

EC4. Not available as full text.

3.3 Selection and data extraction

The selection process was carried out in five stages (see Fig. 1), starting with the execution of the search string in March 2022, where 249 articles were found. It was applied the inclusion and exclusion criteria in stages, reading titles, abstracts and contents. In addition, as indicated by [37], it was decided not to perform quality assessment. After the selection process, 19 articles were obtained as primary studies (see Appendix A)[1].

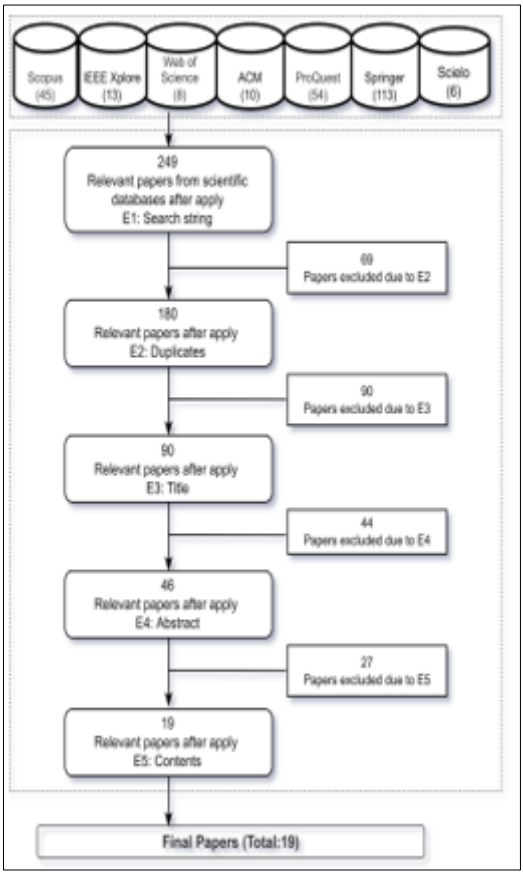

Fig. 1. SMS process selection

To perform the extraction, a spreadsheet was defined with the necessary structure to collect the data (see Table 1). In this table, data from de papers were recorded, and categorized to answer the RQs, see Appendix B. In addition, a pilot was conducted to verify the criteria and determine whether the questions could make sense in a research sample. For this pilot, prior to formal selection, a group of 10 articles with high potential that could become primary studies was extracted. The group was reduced to 7 articles after reading the titles and applying the established criteria. Data were extracted

[1] The whole data from selection process are available at https://drive.google.com/drive/folders/1vURTrYIipJuBQiC2PJIwur4HoatyzzJD?usp=sharing.

from this final group on the extraction sheet and the questions and format could be verified and adjusted.

Table 1. Data extraction item

Data item	Details	RQ
Bibliographic reference	Title, authors(s), year of publication.	RQ1
Paper type	Paper article, paper conference.	RQ1
Name of the journal or conference	Name of the journal or event where the article is published.	RQ2
Process of the ISO/IEC 29110	ISO/IEC 29110 processes that have been used in the academic environment.	RQ3
Pedagogical techniques or activities.	Pedagogical techniques or activities used for learning ISO/IEC 29110 in the academic field.	RQ4
Academic purpose	Academic proposals based on ISO 29110 that contribute to the field of education	RQ5

4. Results

In this section, the results and findings, as well as the validity threats are presented.

4.1 RQ1. How has the number of ISO 29110 publications in university training evolved over time?

As shown in Fig. 2. The evolution, in the number of publications, of ISO 29110 in the university context, has remained almost constant, as it has been published in 2016 (3), 2017 (4), 2018 (3), 2019 (2), 2020 (2). And 2021 (1) However, it is noted that it starts in 2016, which is 5 years after the publication of Part 5-1-2 (software engineering Basic profile) [24]. Furthermore, it should be added that at least the Entry and Basic profiles are freely available from ISO home page.

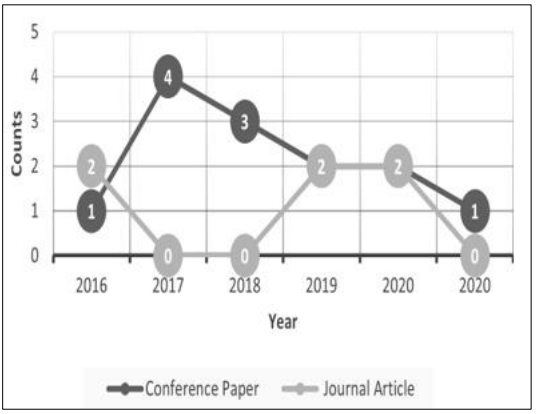

Fig. 2. Studies by type of work and years

Besides, it was noticed that researchers from Latin American have 14 of the 19 primary studies. A possible justification for this is that ISO 29110 is based on MoProSoft, a model developed for the Mexican software industry, and that the ISO working group includes several Latin American researches.

4.2 RQ2. What is the distribution of studies by article type in relation to ISO/IEC 29110 in education?

Fig. 2 shows that the types of articles according to where they were published are conferences (13) and journals (6). On the side of the articles published in conferences (S01, S02, S04, S08, S10, S11, S12, S13, S14, S16, S17, S18, S19) the International Conference on Software Process Improvement

(CIMPS) event stands out, where 3 articles have been published. As for the articles published in journals (S03, S05, S06, S07, S09, S15), the journals Computer Standards and Interfaces and RISTI – Revista Ibérica de Sistemas e Tecnologias de Informação stand out, each with 2 articles.

4.3 RQ3. Which ISO 29110 processes have been addressed in university education?

From the primary studies (see Fig. 3), we have:

Profile level. The most referenced profile is the Basic profile (89%) – (S04, S06), in smaller percentage the Entry profile (11%) – (S01, S02, S03, S05, S07, S08, S09, S10, S11, S12, S13, S14, S15, S16, S17, S18, S19). And no studies are reported for the Intermediate or Advanced profiles. The percentage, in the Basic profile, may be, among others, that it is the first published and certifiable profile, and therefore, of greater interest for companies and researchers. Other possible reasons, attributable to the Intermediate and Advanced profiles, are presented at the end of this question.

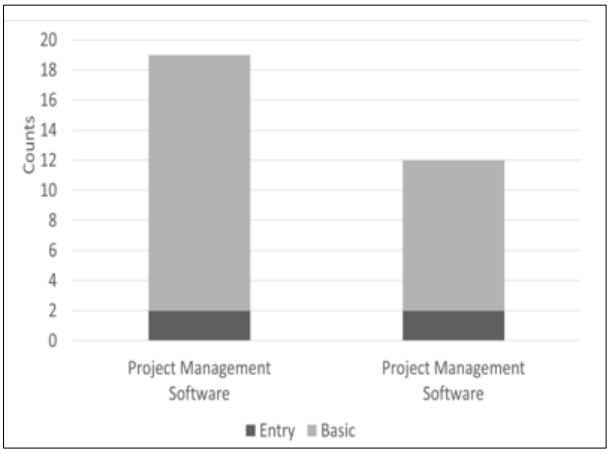

Fig. 3. Activities of the Entry and Basic profiles of ISO 29110

Process level. The most referenced processes are Project Management (19) and Software Implementation (12), both present in the Entry and Basic profiles. No processes have been reported for the Intermediate and Advanced profiles.

Level of processes by profiles. The studies for the Entry profile do not distinguish between the processes so it is understood that they implement both (S04, S06). The studies on Basic profile that only cover the project management process are 7 (S03, S11, S12, S14, S16, S17, S18), and both processes are 10 (S01, S02, S05, S07, S08, S09, S10, S13, S15, S19).

In addition, consulting with experts, there are at least 3 possible causes were identified as to why the Intermediate and Advanced profiles have not been adopted in the university context: (i) the publication of the Intermediate profile was 2017 and of the Advanced profile was 2018 [10] and they have not had the possibility to implement it, a situation accentuated by the pandemic since the end of 2019; (ii) the Intermediate and Advanced profile, focus on an organization that manages multiple projects, something that is unusual in university courses; and (iii) the lack of adequate dissemination of the other profiles in the university environment, accentuated by the COVID-19 pandemic that has forced several changes in university environments.

4.4 RQ4. What kind of pedagogical techniques or activities have been used for learning ISO 29110 in university training?

The application of ISO 29110 in the university environment has been carried out using mainly POL (project-oriented learning) 10 (53%) papers, by the gamification technique 7 (37%) papers and do

not specify the technique in other cases 2 (10%) papers (see Fig.4). The first case, project-oriented learning, involved software development projects within a course where students apply (and learn) ISO 29110 (S02, S03, S04, S05, S06, S09, S13, S14, S15, S18); although it is a controlled context, it offers real opportunities to learn the standard. The second case, the gamification technique, is a practical and enjoyable way to interact with the knowledge associated with the tasks provided in each process considered (S01, S08, S11, S12, S16, S17, S19). Finally, the studies that do not present pedagogical techniques (S07, S10), conducted a comparative analysis of the level of coverage of ISO 29110 with respect to university academic programs.

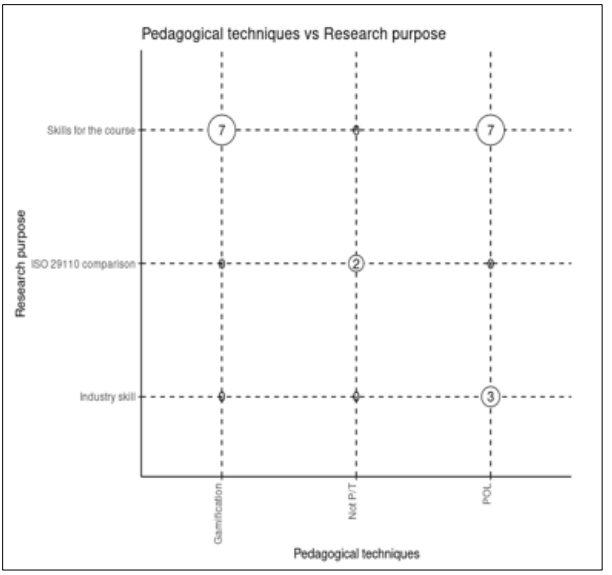

Fig. 4. Pedagogical techniques used for learning ISO 29110 in university environment

4.5 RQ5. What academic purpose is presented in the ISO 29110 studies in the university context?

The main purpose (see Fig. 4) is the development of cognitive skills within an academic course 14 (74%) papers, whose objective is to improve the mastery of ISO 29110 concepts and where the pedagogical techniques of project-oriented learning (S03, S05, S06, S13, S14, S15, S19) and gamification predominate (S01, S08, S11, S12, S16, S17, S018).

On the other hand, 3 (16%) papers of the studies focus on generating technical skills in the management of ISO 29110 applied to cases in the software development industry and use the project-oriented learning technique (S02, S04, S09).

Likewise, 2 (11%) papers of the researches perform an analysis of curricular content versus ISO 29110 activities and do not have pedagogical techniques for this purpose (S07, S10). In these papers, the contents of 4 Mexican curricula (including its courses) of Software Engineering, Computer Science, Computer Engineering and Computer Engineering programs are analyzed and the coverage of ISO 29110 processes and activities is evaluated through a comparative analysis. The analysis of the curricular frameworks with respect to the software engineering Basic profile is performed based on descriptions of both. There are no studies that evaluate the level of adherence to the Basic profile of the projects and results of software development projects carried out by students in their university courses. As can be seen, there is a predominance of ISO 29110 papers in university education that look to generate cognitive skills in students according to their level of education: (i) studies that focus only on undergraduate (S01, S02, S03, S05, S06, S08, S13, S14, S16, S17, S18, S19) cover the last 5 semesters and to Software Quality, Software Engineering I, II or III courses; (ii) in studies

that cover undergraduate and masters (S11, S12 and S15), reinforcements of project management knowledge and software process improvement are described. In addition, two papers (S04, S09) report the participation of undergraduate students in ISO 29110 implementation experiences, which provided them with an enriching experience with real cases from the software development industry. Two studies related to the analysis of course content and its relationship with ISO 29110 activities (S07, S10) have allowed establishing some correspondence between what a student has as potential with respect to what the standard, at the software engineering Basic profile level is expected. Finally, from the synthesis of the conclusions of the papers (see Table 2), it can be noted that: (i) there is an effort to raise awareness among students about the usefulness of 29110 to the industry; (ii) learn the concepts and application of the standard, and (iii) apply techniques such as POL and gamification to achieve the objectives mentioned above.

Table 2. Synthesis of the conclusions from primary studies

id	Contribution
S01	It creates a serious game-based framework for teaching the ISO 29110 standard, however, it has not been implemented.
S02	ISO 29110 was implemented in a university software development center, with students and teachers, based on its own methodology. It was identified that the activities of: evaluation and control of the project management process, as the most difficult for students.
S03	The students who followed the ISO 29110 guide of the implementation process achieved a better quality of the software product.
S04	They manage to verify that it is possible to train students in the development of real software projects using the ISO 29110 standard.
S05	They develop a methodology to achieve ISO 29110 certification and the students evidenced a better understanding of the standard by participating in real projects.
S06	Integrates agile methods, quality standards for teaching ISO 29110, achievn ing an acceptable level of understanding of the concepts of the standard.
S08	A better understanding of ISO 29110 concepts is achieved, based on a monopoly-type board game with roles.
S09	It is determined that a set of deficiencies and lack of skills of a small organization (students) are overcome with the implementation of ISO 29110.
S11	Students achieve course proficiency related to ISO 29110 project management concepts and activities using a serious simulation-based game.
S12	The students acquire the knowledge using a serious game based on the simulation of the ISO 29110 Project Management process for the training of university students.
S13	The results indicate that the solution based on ISO 29110 can be adapted to software engineering student projects.
S14	A monitoring tool for ISO 29110 processes was developed for a better understanding and evaluation of student achievement.
S15	The use of ISO 29110 instead of CMMI facilitated the understanding and implementation of a suitable software engineering framework in the software process improvement course.
S16	A serious game was developed as a way to support the understanding of the ISO 29110 project management process .
S17	Was achieved the understanding and management of the ISO 29110 project management process by students, based in a serious card game.
S018	The game helps teaching and reinforces knowledge of structures and elements of ISO 29110 based on a serious game.
S019	Student participation on process improvement projects with ISO 29110, contributes to the increase of student results in engineering training according to what is established by ABET in the USA or ICACIT in Peru.

4.6 Validity threats

This section presents the validity threats related to study selection, data validity and research validity according to [38] and [39].

4.6.1 Validity of study selection

The procedure consisted of generating and validating the search string through the most popular search engines, such as: Web of Science, IEEE Xplore, ACM DL, ProQuest, Scopus and Springer. In addition, it considered the period between 2011 (the year ISO 29110 was published) and March 2021. The search string was created according to the authors' knowledge about ISO 29110 and university education in software engineering. In the study, 17 articles were selected which were contrasted with the 44 obtained for in the context of education by [4]. From the 17 studies selected, it was determined that 9 studies were considered in the mapping of [4] and the remaining 8, since they are more recent, are not included in Larrucea's mapping [4]. The other 35 Larrucea's studies that were not selected are due to the fact that the author used the concept of education in a more general way and not as something specific to the university environment. Some examples are: frameworks or tools developed based on ISO and applied to educational processes [40], [41], [42]; teaching development teams [43], use of gamification in development teams [44], among others. After obtaining the secondary studies, the articles were distributed to two of the researchers who evaluated the inclusion and exclusion process of the articles; each article received 2 reviews. Finally, a third author randomly reviewed the selection of articles.

4.6.2 Validity of the data

For data validation, the authors held working meetings to discuss the inclusion or exclusion of articles. Statistical tools were not used, since it was not necessary to test hypotheses. The authors have complied with reviewing and applying the stages proposed for the systematic mapping study proposed by [37]. The authors acknowledge that the places of publication of the articles are relevant and of interest to the software engineering community.

4.6.3 Validity of the research

This process considered the experience of the researchers who are familiar with the concepts, methods and terms used in the research, since they have published articles and are reviewers of topics addressed in this research. Likewise, bias and subjectivity are minimized, given that data extraction and data validity were based on the opinion of the first author in contrast to the opinion of the other two authors. Finally, because the Petersen methodology [37] has been followed as reliably as possible, it is certain that the study covers all ISO 29110 investigations in the university setting. However, the number of primary studies does not allow the results to be generalized; but if it has made it possible to identify relevant aspects, they can be used as a basis for future research.

5. Conclusions

In this research, an SMS was defined and performed based on the methodological procedure proposed by Petersen [37], where 17 primary studies were obtained to answer the research questions. It was determined that the software engineering Basic profile and its two processes: Project Management and Software Implementation of ISO 29110, are the most used in the training of university students with respect to the other profiles. The authors of these studies point out that the industries in their countries require people with more competence in ISO/IEC 29110 to provide greater benefits for small software development companies. In this sense, it is important that the university curriculum covers the topics and that the training achieves these competencies in the graduates.

From our study, it is highlighted that two didactic techniques are the most used for students to learn ISO 29110. The first is the didactic technique of project-oriented learning, which provides a space for the experience of skills such as teamwork, holistic vision, critical thinking, and analytical skills in real or realistic situations. The second is the didactic technique of gamification applied with the objective of extrinsically motivating the student to achieve the course objectives.

Moreover, it can be noted that there is a great effort in the field of research in Latin America, which may correspond to the fact that the base of ISO 29110 is MoProSoft. However, from the works of [4] and [45], it can be noted that there are several works that are still being deployed in the industry and more slowly in the academy. Also, here have been studies on the relationship between ISO/IEC 29110 and the curriculum of software engineering programs or related. Such as the verification of the practical exercise or application of ISO 29110 in the courses or projects at the end of the career.

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Appendix A. List of Primary Studies

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S02 J.J. Minero, J. García, and E. Lara. Evaluation of the Implementation of the ISO/IEC 29110 Standard at the Software Development Center from the Institute Technological Superior of Nochistlán. In Proc. of the 9th International Conference on Software Process improvement (CIMPS), 2020, pp. 12-18, doi: 10.1109/CIMPS52057.2020.9390105.
S03 L. Castillo-Salinas, S. Sanchez-Gordon, J. Villarroel-Ramos, and M. Sánchez-Gordón. Evaluation of the implementation of a subset of ISO/IEC 29110 Software Implementation process in four teams of undergraduate students of Ecuador. An empirical software engineering experiment. Computer Standards & Interfaces, vol. 70, 2020, article no. 103430, doi: 10.1016/j.csi.2020.103430.
S04 M. De León-Sigg, J.L. Villa-Cisneros, and B.E. Solísrecéndez. Uso del Estándar ISO / IEC 29110 para Entrenar Estudiantes en Procesos de Ingeniería de Software. RISTI – Revista Ibérica de Sistemas e Tecnologias de Informação, no. 40, 2020, pp. 60-72, doi: 10.17013/risti.40.60-72.
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S06 S.V. Hurtado-Gil. ÁgilUC : Proceso de desarrollo de software para equipos pequeños y una estrategia para su enseñanza. Revista Educación en Ingeniería, vol. 15, no. 29, 2020, pp. 21-27.
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S11 A. Calderón, M. Ruiz, and E. Orta. Integrating serious games as learning resources in a software project management course: The case of ProDec. In Proc. of the IEEE/ACM 1st International Workshop on Software Engineering Curricula for Millennials (SECM), 2017, pp. 21-27, doi: 10.1109/SECM.2017.3.
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S13 N. Chotisarn and D. Sanpote. A demonstration case study of software engineering senior project coordinating the international standard. In Proc. of the International Conference on Digital Arts, Media and Technology (ICDAMT), 2017, pp. 314-319, doi: 10.1109/ICDAMT.2017.7904983.
S14 M. Bougaa, S. Bornhofen, R.V. O'Connor, and A. Rivereю A standard based adaptive path to teach systems engineering: 15288 and 29110 standards use cases. In Proc. of the 11th Annual IEEE International Systems Conference (SysCon), 2017, pp. 1-8, doi: 10.1109/SYSCON.2017.7934712.
S15 C.Y. Laporte and R.V. O'Connor. Software process improvement in graduate software engineering programs. Software Quality Professional, vol. 18, no. 3, 2016, pp. 4-17.

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S17 M. L. Sánchez-Gordón, R.V.O'Connor, R. Colomo-Palacios, and S. Sanchez-Gordon. A learning tool for the ISO/IEC 29110 standard: Understanding the project management of basic profile. Communications in Computer and Information Science, vol. 609, Springer, 2016, pp. 270–283, doi: 10.1007/978-3-319-38980-6_20.

S18 A. Davila, K. Melendez, and M.S.P. Pessoa. University-Enterprise as Educational Space for Students. An Experience in ProCal-ProSer Project. In Proc. of the World Engineering Education Conference (EDUNINE), 2019, pp. 1-6, doi: 10.1109/EDUNINE.2019.8875776.

S19 E. Bonilla-Rivas, M. Munoz, and A. P. P. Negron. Strategy for training in the ISO/IEC 29110 standard based on a serious game. In Proc. of the 10th International Conference on Software Process Improvement (CIMPS), 2021, pp. 74-83, doi: 10.1109/CIMPS54606.2021.9652748.

Appendix B. Primary studies categorized

Id	Year	Paper type	Coverage profile (partial or total)	ISO/IEC 29110 process	Codification: Pedagogical Techniques	Study level	Country of application of the study
S01	2020	Conference Paper	Basic	Project Management Software Implementation	Gamification	undergraduate	Mexico
S02	2020	Conference Paper	Basic	Project Management Software Implementation	POL	undergraduate	Mexico
S03	2020	Journal Article	Basic	Project Management	POL	undergraduate	Ecuador
S04	2020	Journal Article	Entry profile	Project Management Software Implementation	POL	undergraduate	Mexico
S05	2019	Conference Paper	Basic	Project Management Software Implementation	POL	undergraduate	Mexico
S06	2019	Journal Article	Entry profile	Project Management Software Implementation	POL	undergraduate	Colombia
S07	2019	Journal Article	Basic	Project Management Software Implementation	Not apply	undergraduate	Mexico
S08	2018	Conference Paper	Basic	Project Management Software Implementation	Gamification	Not apply	Brazil
S09	2018	Journal Article	Basic	Project Management Software Implementation	POL	undergraduate	Mexico
S10	2018	Conference Paper	Basic	Project Management Software Implementation	Not apply	undergraduate	Mexico
S11	2017	Conference Paper	Basic	Project Management	Gamification	undergraduate and graduate	Spain

S12	2017	Conference Paper	Basic	Project Management	Gamification	undergraduate and graduate	Spain
S13	2017	Conference Paper	Basic	Project Management Software Implementation	POL	undergraduate	Thailand
S14	2017	Conference Paper	Basic	Project Management	POL	undergraduate	France
S15	2016	Journal Article	Basic	Project Management Software Implementation	POL	undergraduate and graduate	Canada
S16	2016	Conference Paper	Basic	Project Management	Gamification	undergraduate	Ecuador
S17	2016	Journal Article	Basic	Project Management	Gamification	undergraduate	Mexico
S18	2021	Conference Paper	Basic	Project Management	Gamification	undergraduate	Colombia
S19	2019	Conference Paper	Basic	Project Management	POL	undergraduate	Peru

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