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# SYSTEMATIC LITERATURE REVIEW ON AGILE FACTORS IN CREATING LEARNING ENVIRONMENT THAT PROMOTES SUSTAINABLE SOFTWARE ENGINEERING COMPETENCIES

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**Abstract:**

In today's ever evolving and dynamic society, lifelong learning and software engineering competency for sustainable development are essential. In current contemporary society, modern instructional materials and frameworks must be employed to assist the transmission of important qualities such as adaptability, creativity, systemic thinking, responsibility, and uncertainty management. Given its deep roots in participative, collaborative, and constructionist ideas, Agile frameworks, which are becoming increasingly popular for project management across several industries, might serve as an effective instrument for conveying these competencies. This paper carries out a systematic literature review to analyse how this modern pedagogical tool will be used to encourage crucial sustainable undergraduate software engineering competencies in the field of software engineering. We employed a systematic literature review methodology in this work. To help researchers conduct systematic reviews, Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) is a robust framework. It goes beyond what is typically included in ordinary literature reviews, which are essentially summaries of earlier research on a particular topic. The time frame of our research is 2019–2024. The biggest database for reliable scholarly papers, Scopus, was searched. After the publications were filtered using the exclusion criteria, 49 eligible papers were chosen for review. Based on the study, twenty-five (25) factors were found, that are useful in communicating competencies. These include strong leadership, team autonomy, collaborative organizational culture, team competency, and sustainable software design. Other Agile factors include code quality, scalability, maintainability, and continuous attention to technical excellence. The software engineering department, instructors and students needs to consider the factors for sustainable undergraduate software engineering competency. It showed that Agile factors assist to create learning

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environment that produce reliable and sustainable undergraduate's software engineering while raising instructors and students' motivation, performance, and satisfaction.

**Keywords:**

Agile Frameworks, Agile Factors, Undergraduate Software Engineering, Sustainability, Competencies

## Introduction

There is curiosity in how Agile methodology affects sustainable software engineering expertise. A thorough evaluation has demonstrated that while enhancing sustainability competencies, agile education fosters a learning environment that is conducive to the development of responsible and sustainable citizens (López-Alcarria, Olivares-Vicente et al. 2019), (Bambazek et al., 2022). Agile project management also encourages sustainability by placing a strong emphasis on solid design and technical proficiency, while although the search results supplied do not specifically address the specific competencies obtained or the influence on sustainability. Agile methodology and practices can contribute to the promotion of sustainability (Gomes Silva et al., 2022). Battaglia, N. (Battaglia et al., 2021) defines a competence as a quality in an individual that enables him to outperform another in a certain role, circumstance, or position; it distinguishes between an average performer and an exceptional performer.

Sustainable software engineering competency is a set of knowledge, skills, and attitudes of software developers to fulfil a given task in a software development project (Nazir et al., 2020), (Tsui, Karam et al. 2022), (AlHamad, Alshurideh et al. 2022). Sustainability is defined as the "capacity to endure" (Heldal, Nguyen et al. 2023). It is a foremost concern in society. However, there is a slight understanding of how it is perceived by software engineers and how it can be established as an integral part of software engineering practices to develop sustainable undergraduate software engineering competency (Yao, Zhang et al. 2022). Besides, "a complete set of abilities, skills, knowledge, and capabilities needed to actively engage in a software development effectively" is referred to as competence. (Assyne et al., 2022b), (Luan & Narayanan, 2024).

Sustainability in software engineering can be the implementation of sustainable development principles into the design, development, and delivery of software engineering curricula in order to promote effective and culturally responsible software development practices (Palacin-Silva et al., 2018).On the other hand, Bröker and Kathrin et al, (2015) described Competences as "the presence of associated motivational, volitional, and social capabilities and skills that are essential for successful and responsible problem solving in variable situations, as well as the learnable cognitive abilities and skills that are needed for problem solving." (Bröker et al., 2015), (Roslan et al., 2024).

Sustainable software engineering is a method that enables software engineers to accomplish developing software products while managing the negative and positive impacts on sustainable software engineering process activities (Nazir et al., 2020), (Meyer, Murphy et al. 2019), (Malik and Khan, 2018), (Othman & Junfeng, 2024). It also refers to the commitment to treat sustainability on a priority basis in software engineering (Caeiro-Rodríguez, Manso-Vázquez

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et al. 2021). Sustainable software is proposed in the Karlskrona Manifesto and encompasses five domains. As described in Figure 1 below.

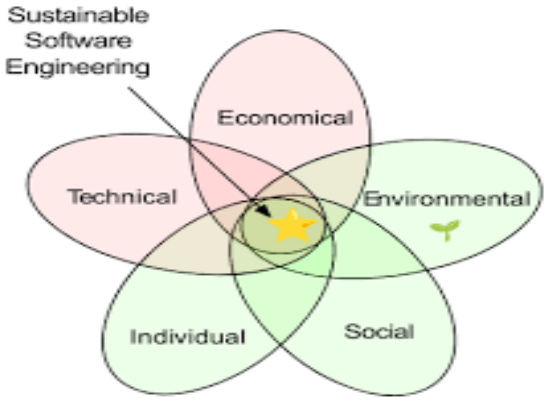


**Figure:1. Five Domains Of Sustainable Software Engineering**

(X Zheng et al., 2021)

The five domains of Sustainable Software Engineering: Individual, Social, Technical, Economic, Environmental as clearly illustrated in Figure 1 above.

1. Environmental: concerned with the long-term effects of human activities on natural systems. This dimension includes ecosystems, raw resources, climate change, food production, water, pollution, waste etc.
2. Social: concerned with societal communities (groups of people, organizations) and the factors that erode trust in society. This dimension includes social equity, justice, employment, democracy etc.
3. Individual: refers to the well-being of humans as individuals. This includes mental and physical well-being, education, self-respect, skills, mobility etc.
4. Economic: focused on assets, capital and added value. This includes wealth creation, prosperity, profitability, capital investment, income etc.
5. Technical: refers to longevity of information, systems, infrastructure and their adequate evolution with changing surrounding conditions. It includes maintenance, innovation, data integrity etc.

Sustainable software engineering involves designing, developing, and maintaining software systems that are environmentally, socially, and economically sustainable, Sustainability in software engineering education is the implementation of sustainable development principles into the design, development, and delivery of software engineering curricula in order to promote effective and culturally responsible software development practices (Palacin-Silva et al., 2018), (Nazir et al., 2020), (Semerikov, Striuk et al. 2020).

**Related work**

According to research, undergraduate students in software engineering should possess competencies in core sustainability concepts, system thinking, soft skills, and ethical considerations (Semerikov et al., 2020), (Heldal et al., 2023), (Palacin-Silva et al., 2018),

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(Assyne et al., 2022b). However, the individual sustainability challenges have less consideration by the researchers (Xinzhu Zheng et al., 2021), (Bolis et al., 2021). The search results suggest that sustainability is a complex and multifaceted issue that requires consideration from researchers and individuals alike (X Zheng et al., 2021), (Purvis et al., 2019), (Kumar, 2020), .

Competency is defined as the possession of sufficient set of skills, abilities, behaviors and knowledge that software professionals need to possess in order to develop high-quality software that contribute to individual and organizational performance (Assyne et al., 2022a). These competencies can be categorized into hard competencies, soft competencies, and essential software engineering competencies (SEC). Competencies in software engineering are not static and can change over time and across projects (Assyne et al., 2022a), (Battaglia et al., 2021). However, AG5 2024 defined skill as the capacity of an individual to perform a certain work or solve a problem with a high degree of proficiency. They are obtained by training, education, and experience. While the term Ability was described by Wikipedia 2024 as the trait or condition of being able to carry out an action or task. It includes a range of dimensions, such as mental, physical, and legal abilities.

Specific application of Agile methodologies in sustainable software engineering is not directly addressed in the provided sources (Molina, 2023). The significant gap between curriculum content, academic aspirations and the software development industry's expectations and requirements (Zeidan and Bishnoi, 2020), (Assyne et al., 2022b). The dearth of primary research on software engineering competency in agile development may also point to a modest lag in the adoption of agile techniques in software engineering education courses (Assyne et al., 2022b).

Individual sustainability challenges are currently faced by undergraduate's software engineering, one of the critical challenges is the lack of competence towards the identification of factors that affect the effectiveness of sustainable undergraduate software engineering competency through agile pedagogical framework/model. The inability to instil undergraduate's with agile methods in a way that fosters long-term software engineering proficiency, is one of the most significant issues (Nazir et al., 2020), (Kropp & Meier, 2014; Motogna et al., 2022).

Further research must examine the competencies needed for creating software products in contemporary development contexts, especially in light of recent moves toward Agile and DevOps methodologies. (Assyne et al., 2022b). Even though agile approaches are widely used in practice and are found in software engineering research. Although sustainable software engineering competency research has not yet given significant consideration to their specificity (Assyne et al., 2022b).

**Existing Review on Sustainable Software Engineering Competency**

According to research, undergraduat's in software engineering should possess competencies on fundamental principles of sustainability, system thinking, soft skills, and ethical considerations (Semerikov et al., 2020), (Heldal et al., 2023), (Palacin-Silva et al., 2018), (Assyne et al., 2022b). However, the individual sustainability challenges have less consideration by the researchers (Xinzhu Zheng et al., 2021), (Bolis et al., 2021).

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Sustainable software engineering competency refers to the knowledge, skills, and attitudes that undergraduates in software engineering should possess to develop sustainable software systems (Marebane & Hans, 2021), (Malheiro et al., 2019), (Juárez-Ramírez et al., 2016). Sustainability in SEE is the application of sustainable development principles into the design, development, and delivery of software engineering curricula in order to promote efficient and culturally sensitive software development practices. Sustainable software engineering entails designing, developing, and maintaining software systems that are environmentally, socially, and economically sustainable (Palacin-Silva et al., 2018), (Nazir et al., 2020), (Semerikov, Striuk et al. 2020), (Ab Hamid et al., 2024).

It is conveyed that undergraduate software engineering' towards developing a deep understanding of sustainability concepts and incorporating them into the software development process is crucial for sustainable software engineering competency. Agile methodology can be used to develop sustainable software systems by incorporating sustainability concepts into the development process and considering the broader system impacts of software engineering decisions (Matthies & Hesse, 2019), (Palacin-Silva et al., 2018), (Semerikov et al., 2020), (Heldal et al., 2023).

**Existing Review on Software Engineering Competency**

Practice experience refers to a structured opportunity for undergraduates to apply their learning in a real-world setting. It allows students to demonstrate their competencies in a practical environment related to their field of study. For example, in the context of public health, practice experience provides students with the chance to apply public health competencies within a public health practice organization (Gold-Veerkamp, 2019). The dimensions of undergraduate software engineering competency can be described using various models and frameworks (Hilburn et al., 2013; Mead & Shoemaker, 2013), (Frezza et al., 2018), (Marebane & Hans, 2021). Here are some important dimensions and competency frameworks as discussed in the following subsections.

***Software Engineering Competency Model (SWECOM)***

The Software Engineering Competency Model (SWECOM) is a framework that defines the competencies required for individuals working in the field of software engineering. It provides a structure for identifying and assessing the specific skills and knowledge needed for different roles within the software engineering discipline (Impagliazzo et al., 2020). SWECOM helps in refining existing software engineering competencies and can be used to develop curricular guidelines for software engineering education (Assyne & Wiafe, 2019). Software engineers that work on creating and changing software-intensive systems might use this model to identify their competencies. At five levels of increasing competency, it lists skill categories, skills within skill categories, and job tasks for each skill. (Frezza et al., 2018), (Assyne et al., 2022a).

***The Essential Competencies of Software Professionals***

The Essential Competencies of Software Professionals (ECSP) framework is a proposed framework for identifying and managing the competencies of software professionals (Assyne et al., 2022a). The framework aims to enable stakeholders to identify software engineering (SE) competencies, identify the essential SEC, and assess the satisfaction levels derived from different competencies (Assyne, 2020). A Unified Competence Framework, this framework proposes a set of basic and essential software engineering competencies (SEC) that software professionals should possess to develop high-quality software (Assyne et al., 2022a).

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***Practice Experience***

Practice experience refers to a structured opportunity for students to apply their learning in a real-world setting. It allows students to demonstrate their competencies in a practical environment related to their field of study. For example, in the context of public health, practice experience provides students with the chance to apply public health competencies within a public health practice organization (Gold-Veerkamp, 2019). Another important dimension of software engineering education is practice experience. This involves hands-on experience in developing software, which can help students apply theoretical concepts to real-world problems (Frezza et al., 2018), (Rendón-Castrillón et al., 2023).

***IEEE Computer Society's Software Engineering Competency Model***The IEEE Computer Society's Software Engineering Competency Model is a framework that outlines the knowledge and skill areas needed for software engineering practitioners. It is based on the Master of Software Assurance reference curriculum and is aligned with the competency model for software engineering practitioners developed by the IEEE Professional Activities Board (Gold-Veerkamp, 2019). This model also describes competencies for software engineers participating in the development and modification of software-intensive systems. It specifies skill areas, skills within skill areas, and work activities for each skill at five levels of increasing competency. Additionally, it includes staffing gap analysis and individual gap analysis worksheets in an appendix (Impagliazzo et al., 2020).

***Engineering Competency Matrix***

An Engineering Competency Matrix is a framework that defines the competencies required for professionals in the engineering workforce. It serves as a guide for career development and training in the engineering field. It provides specific guidance on core competencies and skills needed for individuals entering the engineering field, as well as those required to maintain proficiency throughout their careers (Barrett, 2020). This is a tool that can help teams and companies define expertise issues and increase work efficiency. Software engineers that work on creating and changing software-intensive systems might use this model to identify their competencies. (Schneider & Betz, 2022) (Assyne et al., 2022a).

***Software Assurance Competency Model***

The Software Assurance Competency Model is a framework that assesses and advances the capability of software security professionals. It provides a range of competency levels and decomposes them into individual competencies based on knowledge and skills in the field of software assurance. The model can be used by organizations or individuals to determine software assurance competency and can be adapted to fit specific domains, cultures, or structures (Mead & Shoemaker, 2013). This model focuses on 10 software assurance specialty areas and describes four levels of behaviour for each area. It can be used to assess the competencies of software professionals in areas such as software assurance and security engineering and information assurance compliance (Hilburn et al., 2013), (Marebane & Hans, 2021).

In summary, the dimensions of undergraduate software engineering competency can include interdisciplinary skills, practice experience, communication and technical skills specified in competency models such as SWECOM, Essential Competencies of Software Professionals, Practice experience, IEEE Computer Society's Software Engineering Competency Model, Engineering Competency Matrix, and Software Assurance Competency Model.

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According to Table 1 below, the highest mentioned individual competency factor in the previous study is reflexive, adaptability, and collaboration. There is total nine studies mentioned on this reflexive (Trad, 2019), (Clear et al., 2020), (Semerikov et al., 2020), (Koniukhov & Osadcha, 2020), (Marriott & Martinez-Marroquin, 2021), (Raj et al., 2021), (Bowers et al., 2022), (Alhammad & Moreno, 2022), (Heldal et al., 2023).

**Table 1. Contribution Of Existing Studies For Competency Guideline On Sustainable Agile Software Engineering**

| Author/Year | Individual Competency Factors | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coping with uncertainty | Adaptability | Cognitive | Collaboration | Measurability | Centrality | Emotional intelligence | Operational | Reflexive |
| (Frezza et al., 2018) | | ✓ | | | ✓ | ✓ | | | ✓ |
| (López-Alcarria et al., 2019) | ✓ | ✓ | | ✓ | | | ✓ | ✓ | |
| (Trad, 2019) | ✓ | ✓ | | ✓ | | | | ✓ | ✓ |
| (Clear et al., 2020) | ✓ | ✓ | | ✓ | | | | | ✓ |
| (Semerikov et al., 2020) | ✓ | | ✓ | | | | | ✓ | ✓ |
| (Koniukhov & Osadcha, 2020) | | | ✓ | ✓ | | | | ✓ | ✓ |
| (Marriott & Martinez-Marroquin, 2021) | | ✓ | ✓ | ✓ | | | | ✓ | |
| (Raj et al., 2021) | | ✓ | ✓ | | | ✓ | | | ✓ |
| (Bowers et al., 2022) | | ✓ | ✓ | ✓ | | | | ✓ | ✓ |
| (Alhammad & Moreno, 2022) | ✓ | ✓ | | ✓ | | | | | ✓ |
| (Heldal et al., 2023) | | | ✓ | ✓ | | | | ✓ | ✓ |

On the other hand, also many studies to be precise eight studies talk and discuss about collaboration as the challenges in individual competency factor (Trad, 2019), (Clear et al., 2020), (Koniukhov & Osadcha, 2020), (Marriott & Martinez-Marroquin, 2021), (Bowers et al., 2022), (Alhammad & Moreno, 2022), (Heldal et al., 2023). According to these studies, people are being reflexive due to their desire to be agile and most of the decisions were influenced by top management. However, lack of measurability, centrality and emotional intelligence with team members cause a negative impact to the team performances.

Additionally, aside from emotional intelligence, centrality, and measurability, some of these criteria exhibit a rather significant number of mentions in prior research. There are practices such as adaptability, operational, cognitive, and coping with uncertainty practices. According to the results, certain factors have a high number of mentions while others do not. Conversely, none of the research thoroughly addresses each and every component of individual capability. These studies solely address certain competency characteristics that were found through surveys, investigations, or other specific factors that the researchers wished to evaluate. Consequently, this study will offer a thorough understanding of the individual competency aspects that adversely impact undergraduate software engineering academic programs. According to Gandomani (Gandomani et al., 2013; Saarikallio & Tyrväinen, 2023) Agile

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methods have demonstrated over the last few years that they can solve many of the issues mentioned in the preceding sentence. This approach has established itself as a pioneer in the software development field. Self-organizing groups are at the core of the agile methodology. These self-organizing teams have the authority and capacity to manage their tasks independently. This fact makes the entire development process more productive and allows all employees to learn what they don't know and invent what they believe they need, ultimately making them happy with what they do. A crucial issue for agile adoption is that organizations as well as company's lack of research on how to analyse the level for adoption of agile models in in software engineering academic programs for sustainable undergraduate software engineering competency to transform their approach basically and it has never been an easy process.

**Existing Review on Agile Factors**

Realistic development is greatly altered by the new software development process known as "agile development". The success factors of agile software development have been the subject of numerous studies. In Meenakshi et al.'s 2020 study (Meenakshi et al., 2020), (Ghayyur et al., 2018), (Aldahmash et al., 2017) for instance, the crucial success elements of agile development were suggested. As academic and IT-industries alike transition to agile methodology, research from the past ten years is examined based on many factors such as people, process, and technology. It is possible to analyse important Agile success factors based on the findings of this empirical investigation. A more successful software development team would have well-trained members and effective team communication. To reduce the likelihood that a bug may develop. The prediction of bugs is crucial, various methods and algorithms can be employed to improve the accuracy of the bugs based on past data. Meenakshi et al.'s 2020 study also offered a theoretical evaluation of the success factors for agile development, analysing organizational and people aspects using theoretical research as a foundation. The Chaos Reports, Meenakshi et al., 2020, (Ghayyur et al., 2018), (Aldahmash et al., 2017), state that the following factors are present and contribute to the increased project success rate of the agile methodology. The percentage of responses for a few of the factors are shown below. 15.9% of user's involvement, 13.9% of executive management support, 13.0% of clear requirements, 9.6% of proper planning, 8.2% of realistic expectations, 7.7% of smaller project milestones, 7.2% of competent staff, 5.3% of ownership and 13.0% of clear vision and objectives, 2.9% Industrious.

**Research Questions and their Motivation**

In view of the theoretical underpinnings that have been covered thus far in this article, our goal is to conduct a thorough systematic literature review to investigate publications that offer various perspectives on the implementation of Agile factors in relation to software engineering competencies context. We postulate that using Agile factors and frameworks is the best way to help students develop their capabilities in a transverse and multidimensional manner. This way, they can continue to develop on these abilities or competencies even when they are enrolled in courses and programs unrelated to sustainable development.

i. RQ1: What is the observed facts or evidence in literature for application of Agile factors in sustainable software engineering competency?

ii. RQ2: Can the distribution of sustainability competencies be improved by the application of Agile factors?

iii. RQ3: If RQ2 is true, is this transmission intentional and purposeful, or is it the outcome of using pedagogical framework, which Agile frameworks build upon?

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The following reasons underpin these study questions: (a). Provides a collection of pertinent publications from the literature on software engineering that embraces agile methodologies. (b). Check to see, if an analysis of the communicated sustainability competences was completed and (c). Ascertain whether instructors and students understand the value of the skills they have learned for development and sustainable competency.

**Methodology**

A powerful framework by Page et al., 2021 called Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) was created to assist researchers in carrying out systematic reviews. It extends beyond the purview of standard literature reviews, which are generally summaries of prior studies on a given subject. A systematic review, on the other hand, is an exhaustive and rigorous examination of the literature that is especially intended to address a clearly stated research topic. Science Direct, Google Scholar, Scopus, IEEE Xplore, ACM Digital Library and Web of science.

Selection rules (Zhang et al., 2020) to identify the works that meet the requirements for at least minimal scientific soundness and quality. Initially, we performed a manual search of the ACM Digital Library, Science Direct, Google Scholar, IEEE Xplore, Scopus, and Web of Science papers, there are several renowned meta search engines that index thousands of articles from various publishers and journals. The Web of Science is particularly pertinent among them since it is focused on the sciences, meaning that the outcomes should be more limited. However, although Scopus searches all the most significant databases from the biggest publications, it serves a more general function. The same query was employed in both databases, aiming to obtain results including the three pillars of this review: (i) Agile factors/frameworks (ii) undergraduate software engineering (iii) Sustainable software engineering competencies. Two different versions of the query were built as IEEE Xplore search engine does not support the "*"regular expression:

1). Scopus Query: ((“agile” AND “frameworks”) OR ( “agile” AND “sustainable software engineering” ) OR ( “agile” AND “methodologies” AND “software engineering” ) OR ( “agile” AND “sustainability” AND “competencies” ) OR ( “agile” AND “competencies” AND “undergraduate” ) OR ( “agile” AND “sustainability” ) OR ( “pedagogical” AND “agile” AND “education”) ).

2). Web of science Query: ((agile AND software) OR ( agile AND sustainability ) OR ( agile AND sustainability AND competency ) OR ( agile AND factors AND competency ) OR ( agile AND competency AND learning ) OR ( agile AND factors AND sustainability ) OR ( agile AND education AND competencies) ).

There are 258 results from 2019 to 2024 in the Scopus search, Conversely, Web of Science yields 178 hits for the same query for the same time. Though less constrained, the Scopus results contained important papers that were published on IEEE Xplore, which is possibly the biggest database for computer and software engineering education. Followed by ACM digital library. Most IEEE Xplore findings. However, were not included in the Scopus results, which were more pertinent to the subject by far. After that, all search results were filtered according to the work's title and all three authors reviewed the abstract whenever they weren't sure. After the initial stage of filtering, 690 out of the 1263 results were fully read and examined. After a second selection process that focused on identifying works that presented Agile software engineering and specifically mentioned the development of sustainable software engineering competencies, 49 works were left for consideration in the systematic literature review. The

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selection criteria are displayed in Table 1.1 below. The PRISMA 2020 flow diagram, which is shown in Figure 2 below, provides a detailed presentation of the screening process.

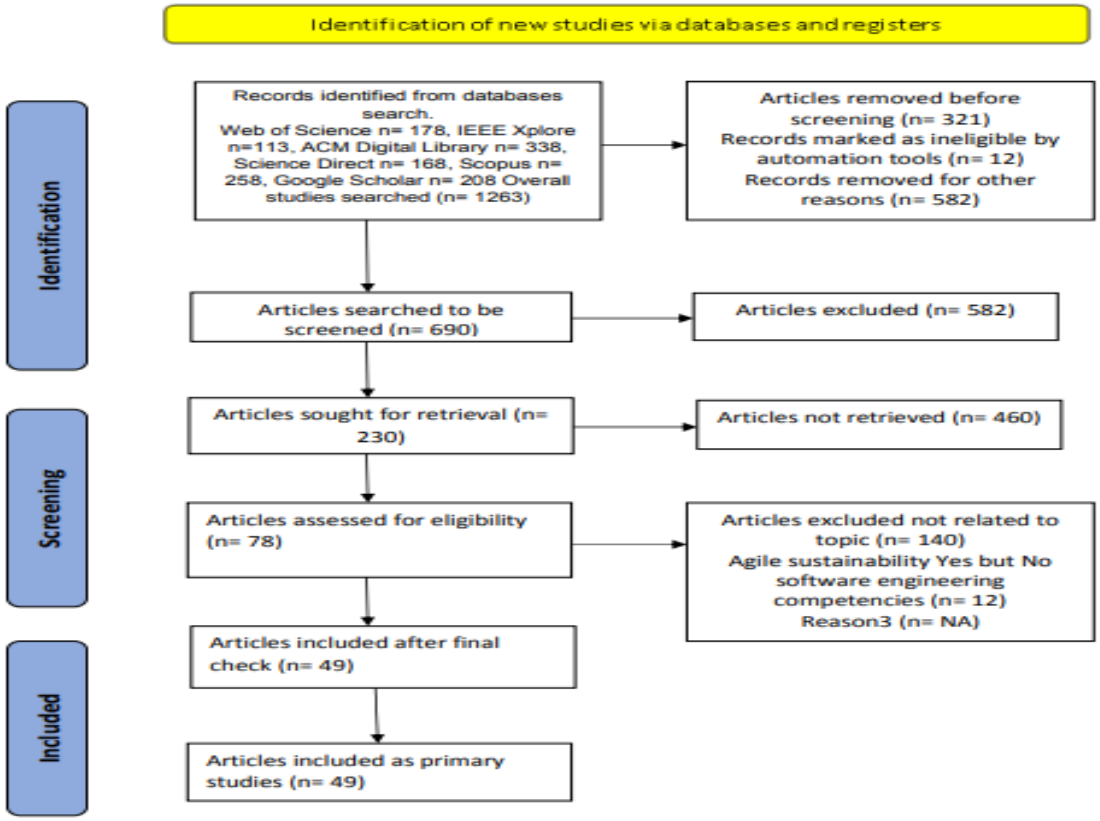


**Figure 2. PRISMA 2020 Flow Diagram for Updated Systematic Reviews via Databases**
(Haddaway et al., 2022)

**Documentation**

This concludes the third and last section of the systematic literature review. It offers thorough analysis along with inclusion and exclusion criteria. The study sources are shown in Table 1.1 below, that is the journal articles that were included and those that were excluded from the systematic literature review are listed in Table 1.1 below.

**Table 1.1. Screening Process Conducted Using Selection Criteria.**

| Component | Criteria for selection |
|---|---|
| Agile frameworks | Class teaching setting implemented by Agile |
| | Group assignments and capstone projects are managed using Agile |
| | Curriculum or syllabus defined by Agile. |
| | Course sessions were organized using Agile. |
| Learning based on competencies | Proof of competencies conveyed/delivered via Agile. |
| Sustainability for education | Proof of sustainable competencies conveyed through Agile application. |
| Education Level | All levels with special emphasis on higher education. |
| Location | Malaysia UTM Johor. |

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| Language | English |
|---|---|
| Inclusion criteria | Exclusion criteria |
| papers regarding agile frameworks, sustainable competencies using software engineering those that are not peer-reviewed, though the inclusion criteria were met. | Peer-reviewed papers regarding sustainable software engineering competencies, including research survey and case study. |
| literatures that pertain to agile frameworks, sustainable software engineering competencies published before the year 2019. | peer-reviewed papers regarding sustainable software engineering competencies through agile frameworks. |
| papers or research reports that discusses information out of the academic scope. | Peer-reviewed papers that pertain sustainable software engineering competencies. |
| pedagogical agile frameworks business reports. | Literatures relating to pedagogical agile frameworks, sustainable software engineering competencies published between the year 2019 and 2024 |

As per the inclusion and exclusion criteria provided by (Podari et al., 2020) was adhered to. The necessary information or data for this systematic literature review paper was extracted in accordance with (Quezada-Sarmiento et al., 2020) standards for systematic literature reviews. Every article that was taken and used for this paper was organized using Endnote X9, including the Bibliography and Citation.

**Benefits of Sustainable Undergraduate Software Engineering Competency**

A sustainable undergraduate degree in software engineering has several advantages, such as addressing environmental effects, helping to fulfil UN Sustainable Development Goals, encouraging moral behaviour, and improving software development's long-term sustainability (Hazzan, 2021). A sustainable software engineering competency highlights how crucial it is to incorporate sustainability ideas into computer science and software engineering courses in order to give students the tools they need to create software that is favourable to the environment (Li et al., 2023). Additionally, this competency promotes the growth of social and cognitive abilities or exponential competence, which is essential for students pursuing these careers. Furthermore, instructing engineering students on professional ethics and sustainable development can benefit humankind and assist avert disastrous occurrences (Heldal et al., 2023).

**Collection Criteria and Analysis**.

The approach described by the review activity in the part that follows (methodology) was used to search primary sources and the necessary data was acquired from a variety of well-known publications and conference proceedings that were accessible through several digital libraries. Appendix A contains the sources that were examined and presented. (Table 1.2: collection source 2019 to 2024).

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## Result and Discussion

Figure 3 below presents the publications year-wise trend for SUSEC through Agile framework since 2019 to 2024. While Figure 4 present Major Studies Contribution, however, Figure 5. Present major Approaches Contribution in relation to primary study.

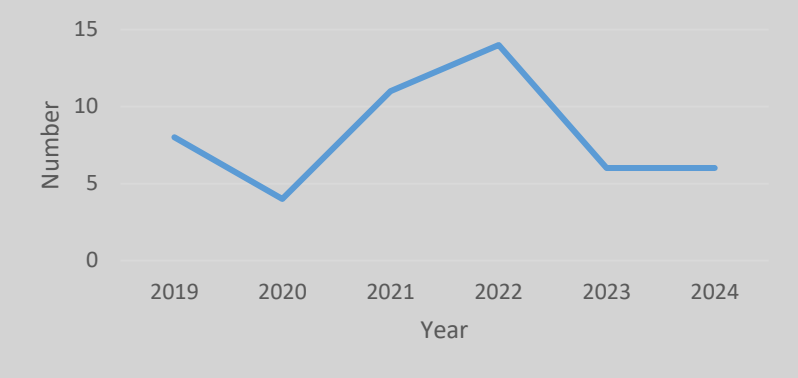


**Figure 3. Publication Year-wise Trend**

As shown in Figure 3 above, with fourteen (14) papers, the articles published in 2022 made the most contribution, followed by those released in 2021 with eleven (11) study materials. However, there were eight (8) papers from 2019 that were used in this evaluation, compared to six (6) papers each from 2023 and 2024 respectively. By year 2020 only produced four (4) papers. Moreover, Appendix A contain details including ISBN of the articles. The solution to the research questions is briefly described in the following section.

***RQ1; What Is The Observed Evidence In Literature For Application Of Agile Factors In Sustainable Software Engineering Competency.***

As described in Figure 3 above presents the publications year-wise trend for application of Agile factors in sustainable software engineering competency through Agile framework since 2019 to 2024. RQ1, covers major factors, following hundreds of search results, we can say with certainty that the literature does contain empirical evidence supporting the applicability of Agile principles to software engineering competency (Khan et al., 2021), (Putta, 2022). Nonetheless, they demonstrate how agile frameworks are becoming more and more popular in a variety of industries, including education. Interestingly, how over the past few years, the quantity of experiments and experiences has increased tremendously. Primarily, its utilization is beginning to take off in non-engineering domains where the framework was developed; it is a framework with enormous potential for applicability in any kind of educational setting and subject matter. Agile factors identified for sustainable undergraduate software engineering competency through SLR. Our thorough literature research includes the identification and classification of twenty-five (25) Agile factors. The agile factors to achieve sustainable software engineering competency include leadership strong commitment, team autonomy, cooperative organizational culture, team competency, sustainable software design, code quality, scalability, maintainability, continuous attention to technical excellence, good design, internal quality, easily understandable code, agility in accommodating future changes, and embracing lean-agile mindset and principles (Khan et al., 2021), (Alami & Krancher, 2022), (Putta, 2022). Moreover, according to Khan (2021) customer engagement, sustainable planning, efficient software processes, deployment of software systems, competency-based management are among the identified factors (Khan et al., 2021), similarly, Alami,

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Adam(2022) reiterate the following factors as very significant to achieving sustainable software engineering competency these include iterative development, formal inspection, adaptation and transparency, internal quality emphasis, social antecedents, process-induced advantages (Alami & Krancher, 2022). These factors emphasize the importance of quality, adaptability, and continuous improvement in software development processes to ensure sustainability and efficiency. Figure 4 shows the classification of these factors.

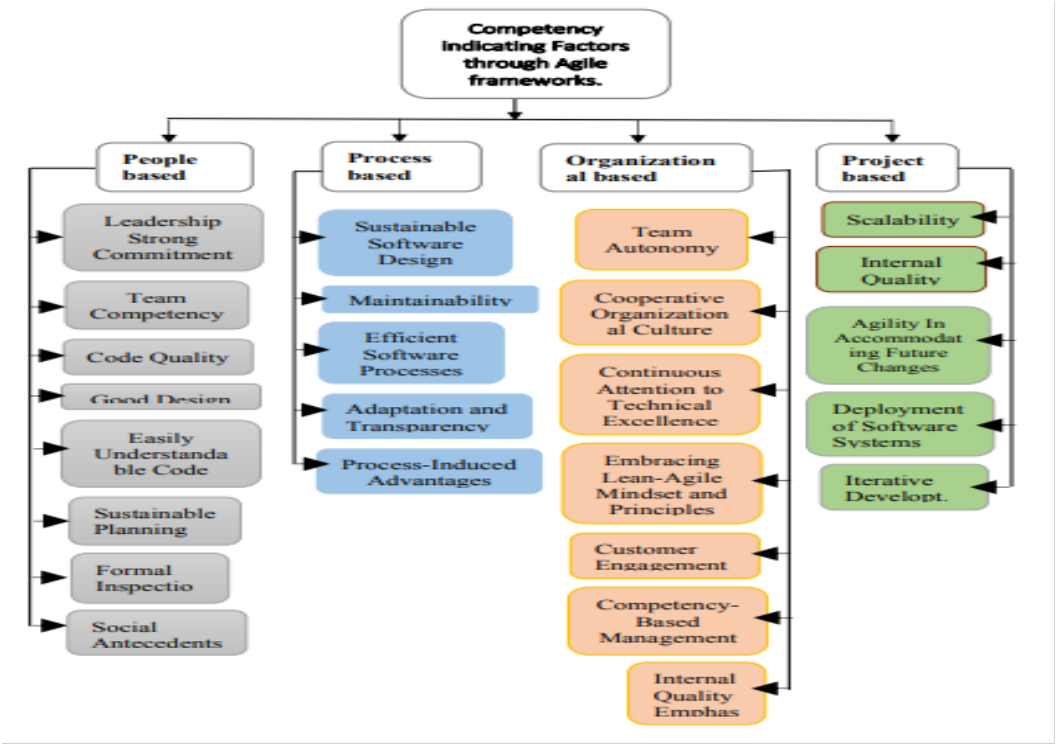


**Figure 4. Classification of Competency indicating Factors through Agile frameworks**.

***RQ2; Can The Distribution Of Sustainability Competencies Be Improved By The Application Of Agile Factors.***

Considering how Agile Methodologies can be used to promote and enhance the transfer of critical abilities and with respect to how sustainability competencies are applied. It has been demonstrated that many of the competencies that the authors identified as either the primary goals of their Agile Education experiments or incidental observed results are, in fact, competencies that have been identified as critical competencies by several authors. As a result, we have seen how using the artifacts outlined in the methodology necessitates applying skills like dialog, critical thinking, and uncertainty management. According to the authors, the prime advantages of using Agile factors with students are the development of all these competencies. Furthermore, authors have demonstrated that the primary benefits of using Agile factors are the attainment of all these competencies. The categories of sources employed in this study are analysed in Figure 5 below, which is referred to as the contribution source.

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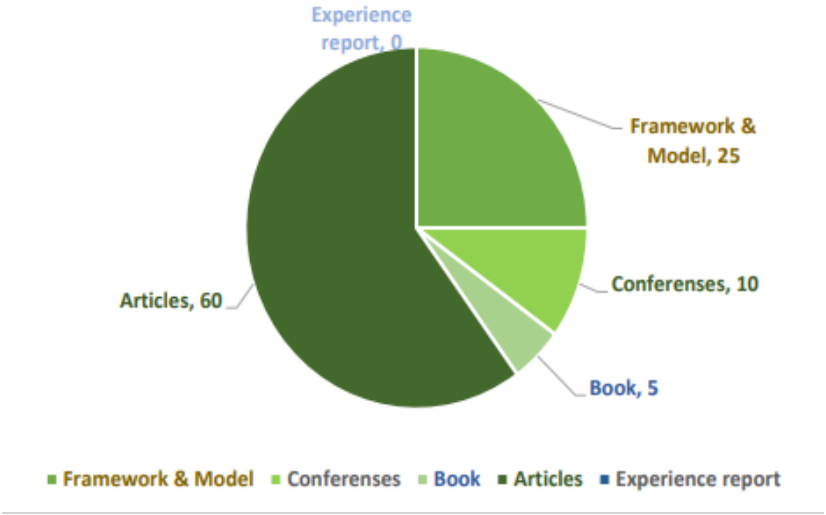


**Figure 5. Major Studies Contribution**

A count of the journals, books, experience reports, frameworks/models, conference proceedings, and reports that were acquired for this review is presented in Figure 5. The largest collection of contributing sources that we used for our review was articles relating to (60%) and frameworks and model-related studies (25%) came next. However, conference-related papers accounted for 10% of the overall number of articles. Similarly, books accounted for 5% of all the articles submitted. Conversely, our research and findings point to a deficiency in experience reporting from contributing sources as described in Figure 5 above.

***RQ3; If RQ2 Is True, Is This Transmission Intentional And Purposeful, Or Is It The Outcome Of Using Pedagogical Framework, Which Agile Frameworks Build Upon.***
Research has demonstrated that these competences are sometimes intentionally transmitted, as they are included in the stated goals of the course that will be taught using Agile frameworks. Teachers and students have noted these competencies as a beneficial result.

According to the articles and kind of contributions that have been made, we systematically identify factors base on contributing articles and contribution type. An organized summary of recent research is shown in Figure 6 below. The mixture or combination of selected research factors and categorization methods. However, it is imperative to ensure that the recently established high-quality classification approaches and primary selected studies are utilized.

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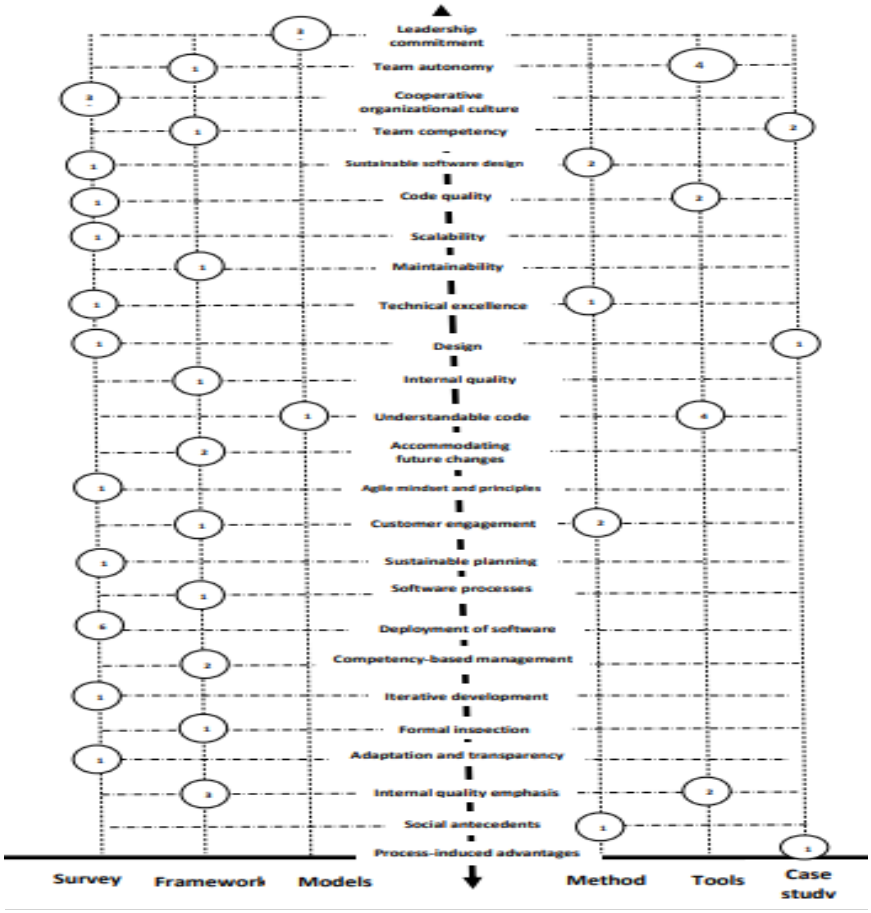


**Figure 6. Major Approaches Contribution In Relation To Primary Study**.

The comparison shown in Figure 6 above make sure that the survey, framework, models, study method case study and tools chosen to provide high-quality classification procedure eventually. The authors did not create any particular programs for the development of competences in any of the examples. Interestingly, though, they ultimately worked on these competencies in a transversal and multidisciplinary manner, which is one of the things that made the learning more lasting and meaningful (Alami & Krancher, 2022).

## Conclusion

This systematic literature research set out to identify the Agile factors that affect the effectiveness of sustainable undergraduate software engineering competency. Based on the sources and types of contributions, SLR determined the Agile factors. With a focus on suggested frameworks, this offers a methodical summary of recent research. Furthermore, based on the study, twenty-five (25) factors were found, that are useful in communicating competencies in this study. The software engineering department, instructors and students needs to consider the factors for sustainable undergraduate software engineering competency. It is proved that Agile factors creates a learning environment beneficial to produce responsible and sustainable undergraduate software engineering competency while raising instructor and students' motivation, performance, and satisfaction.

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From RQ1, following hundreds of search results, we can say with certainty that the literature does contain empirical evidence supporting the applicability of Agile principles to software engineering competency based on our systematic literature review discussion. Likewise, RQ2; With respect to how sustainability competencies are applied, it has been demonstrated that many of the competencies that the authors identified as either the primary goals of their Agile Education experiments or incidental observed results are. For RQ3, our systematic literature review has demonstrated that these competences are sometimes intentionally transmitted, as they are included in the stated goals of the course that will be taught using Agile frameworks. Teachers and students have noted these competencies as a beneficial result. The field of agile frameworks has a large potential for future research; we recommend this will provide a chance to integrate emerging technologies into our work, by investigating the role of emerging technologies like artificial intelligence (A.I) and machine learning (ML) might improve agile learning environment.

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## Appendix A

**Table 1.2: Collection Source 2019 to 2024**

| **Collection Source 2019**<br>**Journal = 4. Conference = 3. Book= 1. Total = 08.** | | |
|---|---|---|
| **Paper type** | **Title Source** | **ISSN//Acronym** |
| Journal | A systematic review of the use of agile methodologies in education to foster sustainability competencies | 2071-1050 |
| Conference | Identification of the agile mindset and its comparison to the competencies of selected agile roles | 3030375331 |
| Conference | Situational factors affecting software engineers' sustainability: A vision of modern code review | 172814082X |
| Journal | Investigating students' sustainability awareness and the curriculum of technology education in Pakistan | 2071-1050 |
| Book | Software Engineering Ninth Edition by-Ian-Sommerville | 0137035152 |
| Journal | Motivators for large-scale agile adoption from management perspective: A systematic literature review | 2169-3536 |
| Conference | Sustainability and agility in project management: contradictory or complementary | 3030010686 |
| Journal | Improvement of students critical thinking through the using of the method of case studies | 2254-6529 |
| **Collection Source 2020**<br>**Journal = 03. Conference = 1. Total = 04.** | | |
| **Paper type** | **Title Source** | **ISSN//Acronym** |
| Conference | An agile holistic framework to support teachers in pedagogical gamification design | 1728144523 |
| Journal | Implementation of agile methodologies in an engineering course | 2227-7102 |
| Journal | An empirical study on predictability of software maintainability using imbalanced data | 0963-9314 |
| Journal | An overview and comparison of supervised data mining techniques for student exam performance prediction | 0360-1315 |
| **Collection Source 2021**<br>**Journal = 12. Conference = 0. Total = 11.** | | |
| **Paper type** | **Title Source** | **ISSN//Acronym** |
| Journal | The state of research on software engineering competencies: A systematic mapping study | 0164-1212 |
| Journal | Digital learning and digital institution in higher education | 2227-7102 |
| Journal | Sustainability in Software Engineering Education: a case of general professional competencies | 2267-1242 |
| Journal | Proposal of a sustainable agile model for software development | 2158-107X |
| Journal | Software Engineering Competence-Based Learning in Collaborative Virtual Environments | 1665403020 |
| Journal | Software Engineering Competence-Based Learning in Collaborative Virtual Environments | 1665403020 |
| Journal | Improving teamwork in agile software engineering education: The ASEST+ framework | 0018-9359 |
| Journal | Comparing methods for large-scale agile software development: A systematic literature review | 0098-5589 |
| Journal | Incorporating CC2020 and SWECOM competencies into software engineering curricula: A tutorial | 1728168074 |

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| Journal | An agile framework for teaching with scrum in the IT project management classroom | |
| Journal | Attempting to break the chain: reimaging inclusive pedagogy and decolonising the curriculum within the academy | 0013-1857 |
| **Collection Source 2022**<br>**Journal = 14. Conference = 0. Total = 14.** | | |
| **Paper type** | **Title Source** | **ISSN//Acronym** |
| Journal | Entrepreneurial Competencies, Competitive Advantage, and Social Enterprise Performance: A Literature Review | 9462395322 |
| Journal | Applying agile framework in delivering, and evaluating university courses | 1741-9174 |
| Journal | Do Agile Managed Information Systems Projects Fail Due to a Lack of Emotional Intelligence | 1387-3326 |
| Journal | Improving agile software development using user-centered design and lean startup | 0950-5849 |
| Journal | A case study on implementing agile techniques and practices: Rationale, benefits, barriers and business implications for hardware development | 2076-3417 |
| Journal | Tensions in organizations transforming to agility | 0018-9391 |
| Journal | A teamwork effectiveness model for agile software development | 1382-3256 |
| Journal | The essential competencies of software professionals: A unified competence framework | 0950-5849 |
| Journal | Full-stack Development and Soft Skills: An Agile-based Learning Framework | 2371-5243 |
| Journal | Sustainability in Agile Software Development: A Survey Study among Practitioners | 1665482869 |
| Journal | Advancing Computing Education: Assessing CC2020 Dispositions | 1665462442 |
| Journal | Software, Sustainability, and UN Sustainable Development Goals | 1520-9202 |
| Journal | Digital demand and digital deficit: Conceptualising digital literacy and gauging proficiency among higher education students | 1360-080X |
| Book | Adopting Agile Methods in Large-scale Organizations using Scaling Frameworks | 9526409957 |
| Journal | How Scrum adds value to achieving software quality? | 1382-3256 |
| **Collection Source 2023**<br>**Journal = 5. Book = 1. Total = 6.** | | |
| **Paper type** | **Title Source** | **ISSN//Acronym** |
| Journal | DevOps critical success factors—A systematic literature review | 0950-5849 |
| Journal | Competencies for code review | 2573-0142 |
| Journal | Junior Software Engineers' International Communication and Collaboration Competences | 2169-3536 |
| Journal | Leading the transformation: Agile success factors in an Irish manufacturing company | 1478-3363 |
| Book | Agile Software Engineering Skills | 3031054695 |
| Journal | Sustainability competencies and skills in software engineering: An industry perspective | 0164-1212 |
| **Collection Source 2024**<br>**Journal = 6. Book= 1. Total = 06.** | | |
| **Paper type** | **Title Source** | **ISSN//Acronym** |
| Journal | Factors Affecting Agile Software Project Success | 2169-3536 |
| Journal | Navigating Digital Transformation: Current Trends in Digital Competencies for Open Innovation in Organizations | 2071-1050 |
| Journal | The intertwined effects of digital literacy, agile mindset on design thinking skill and management control competency: Insights from Thai young accountants | 2667-0968 |
| Journal | Sustainability competencies and skills in software engineering: An industry perspective | 0164-1212 |

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|---|---|---|
| Journal | The effectiveness of agile leadership in practice: A comprehensive meta-analysis of empirical studies on organizational outcomes | 2299-7075 |
| Book | Agile Competencies—The Way to Manage Talent in an Agile Organization | 9819995507 |
| Journal | Applying TPACK in STEM Education towards 21-st Century: Systematic Literature Review | 2226-6348 |