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Agile Software Development with Secure and Scrum-Centric Approach

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ABSTRACT

The fulfillment of agile models is crucial for ensuring that a software development project's tasks are completed efficiently and collaboratively. The definitions of the project architecture are usually performed in these models. Factors such as delivery time, cost and maintenance are determined. In traditional methods, project stages are carried out sequentially. After one of the stages is completed, another one is performed. When an innovation or change is attempted at any point in the project, some problems occur. These problems can generally be solved with Scrum agile methods, where communication is highlighted and processes are performed more flexibly. It is an undeniable fact that Scrum and security issues can be brought together when incorporating the Scrum strategy into software development models. In such a case, models are used that allow Security and Scrum to work within a framework. In this study, scientific studies based on scientific evidence aimed at eliminating incompatibilities in software development systematics were analyzed. The distribution of the publication years, the relation of scrum and security, the citation topic, the bibliometric maps and co-citation report are used in these analysis. In the result of these analyses, bibliometric and statistical analysis results of studies in the literature on software development that includes security principles with the Scrum model were revealed. When the results obtained in the experiments were examined, it was concluded that it was possible to develop secure software with an architecture in which Scrum and Security models were used together. During the software development phase, it enables proactive risk management by blending scrum and security elements. It also allows teams to detect security vulnerabilities during the software development phase. These facilitate the creation of a more secure and durable software product.

Keywords **:** Agile Software Development, Scrum, Security, Statistical and Bibliometric Analysis

Güvenli ve Scrum Merkezli Yaklaşımla Çevik Yazılım Geliştirme

ÖZ

Çevik modellerin yerine getirilmesi, bir yazılım geliştirme projesinin görevlerinin bir arada yürütülmesi açısından önemlidir. Proje mimarisinin tanımları genellikle bu modellerde yapılmaktadır. Teslimat süresi, maliyet, bakım gibi faktörler belirlenir. Geleneksel yöntemlerde proje aşamaları sıralı olarak yürütülür. Aşamalardan biri tamamlandıktan sonra diğerine geçilir. Projenin herhangi bir noktasında bir yenilik veya değişiklik yapılmaya çalışıldığında bazı sorunlar ortaya çıkar. Bu sorunlar genel olarak iletişimin ön plana çıkarıldığı ve süreçlerin daha esnek yürütüldüğü Scrum çevik yöntemleriyle çözülebilmektedir. Scrum stratejisinin yazılım geliştirme modellerine dâhil edilmesinde Scrum ve güvenlik konularının bir araya getirilebileceği yadsınamaz bir gerçektir. Böyle bir durumda Security ve Scrum'ın bir çerçeve içerisinde çalışmasına olanak sağlayan modeller kullanılır. Bu çalışmada

yazılım geliştirme sistematiğindeki uyumsuzlukların giderilmesine yönelik bilimsel kanıtlara dayalı bilimsel çalışmalar analiz edilmiştir. Bu analizlerde literatürde Scrum modeli ile güvenlik ilkelerini içeren yazılım geliştirme çalışmalarının bibliyometrik ve istatistiksel analiz sonuçları ortaya çıkarılmıştır. Deneylerde elde edilen sonuçlar incelendiğinde Scrum ve Security modellerinin bir arada kullanıldığı bir mimari ile güvenli yazılım geliştirmenin mümkün olduğu sonucuna varılmıştır.

Anahtar kelimeler : Çevik Yazılım Geliştirme, Güvenlik, İstatistiksel ve Bibliyometrik Analiz, Scrum.

INTRODUCTION

The various stages are performed sequentially in developing software. In the first stage, planning, the goals of the project are determined, resources are allocated, a calendar is created and general strategies are determined. In addition, project scope, budget, and timelines are determined at this stage. In the next phase, Analysis, user needs are determined, system requirements are collected and analyzed. During the design phase, the software architecture is created based on the results of the analysis. In the Implementation phase, software developers create software codes in accordance with the determined design. In the testing phase, tests are carried out to identify errors and deficiencies. In Deployment, the software is made available to users. The last phase, Maintenance, and Update, includes processes such as bug fixes, security updates, and new feature additions. There are different stakeholders at each stage. These stakeholders are the Product Owner, Development Team, Customer, Managers, and External Vendors or Suppliers. However, faulty planning in the software development stages, changing user requirements, insufficient budget, late delivery of the project, user interface updates, and updates at the end of user experiences are problems that need to be solved. The agile methods are required to solve this problem by managing the dependencies and interactions between these stakeholders in software development (Behutiye et al., 2020). The scrum methodology is recommended in the literature to solve these problems that may occur with agile methods (Zagita & Raharjo, 2023).

In the literature, various details were given regarding the use of both methods together. In the Scrum methodology, collaboration and communication with stakeholders are used in the software development process. Feedback in Sprint Reviews in Scrum helps adapt the project backlog and improve the project. In particular, effective engagement with stakeholders contributes to the overall success of Agile projects. It has been stated that there are some distinctions between software security and Scrum strategy (Khan et al., 2024). For this reason, it was stated that treating security processes as a support mechanism is not optimal (Altunel et al., 2022). This can be addressed by empowering product owners. The interaction can be created more easily and security issues can be used with agile software design with this authorization (Nayaka et al., 2024).

The success of the software includes its management and development teams can do work broken down into smaller pieces in Scrum strategy. Also, a different environment is created where the individuals involved in the project can carry out different responsibilities (Joskowski et al., 2023). Although the Scrum strategy contributes to agile software development, there is no activity related to secure software development in this methodology. Security can only be ensured with various extensions (Pattaranantakul et al., 2023). It has been determined in detail in some studies that these extensions can be included in the Scrum strategy (Peldszus, 2022). Some studies have stated that there are some difficulties in using security issues in agile software development. Despite this, software development models in which both strategies are used together were discussed (Casola et al., 2024). This is a striking output that makes it possible to evaluate Scrum strategy and security processes together. The most important parameter in this process is the creation of the support path. Thus, teams in Scrum can collectively make it clear what supports and hinders the security issues (Baxter et al., 2023).

In this study, a statistical and bibliographic analysis was presented regarding the incorporating security issues in agile software development using Scrum. Experimental studies were conducted using the research question (RQ) and RQ2 posed with the scope. The web of science (WOS) analytics and Vos Viewer were used in experimental studies. The findings of the analysis emphasizing that interaction and agile methodologies are essential components in addressing security concerns.

1. RELATED WORKS

The WOS-linked databases were selected as software development studies that include agile and security processes with the Scrum method in the proposed study. The literature survey was performed with the science citation index, science citation index expanded and emerging science citation index by using the WOS system. In these studies, the main focus is on the analysis of security and Scrum agile software development methods. It is stated that some basic elements are related to security. The Security Development Lifecycle (SDL) is a methodology that focuses on embedding security issues throughout vulnerabilities. Comprehensive Lightweight Application Security Process (CLASP) provides an application security framework. The Common Criteria (CC) is an international certifying the security progress. The Touchpoints (CT) appointed the key stages in security issues (Sheikh & Singh, 2023; Mihelič et al., 2023; Canedo et al., 2023; Oyetoyan et al, 2019).

The previous studies presented with the motivation of software development strategy with the Scrum method performed the contributions to Security issues and Scrum methodology, together.

Sharma & Bawa examined security integrations to the Scrum software development environment. The authors stated that offering services and products in smaller groups would

contribute to security. They also found that security experts can easily adapt to agile methodologies in software development. These findings provide valuable information for the development of new strategies for successfully integrating security in agile development processes (Sharma, & Bawa, 2022).

Tøndel et al. performed security cases in agile software development. In the case analysis presented by the authors, activity-oriented models and the impact of existing models on security were examined. As a result, a framework for understanding and managing security in agile software development processes could be presented. The factors that determine the priority of security in software development projects were revealed. By introducing these factors, security issues can be addressed more effectively in agile software development practice (Tøndel et al., 2022).

Bayram et al. surveyed agile software development research presented in the literature from 2013 to 2018. The data collected for the research was analyzed. A two-stage research method was preferred by the authors. Data were collected from various academic databases and relationships between publications, researchers, institutions, publication sources, and countries were revealed. Experimental results show that developing countries produce more studies in this field, cited publications mostly come from developed countries, distant countries show more cooperation, and the number of citations is not directly related to the number of publications (Bayram et al., 2022).

Gomero-Fanny et al. discussed designing a web application with Scrum and Security. This web application presented an e-commerce site. This site was related to the Scrum model. The model adopted for the prototype is focused on security. However, communication between stakeholders is continuous. This is a parameter in the effective solution of problems that may arise. The sprints were evaluated with some scores. This scoring was used by the authors to evaluate progress in the software development process and optimize the team's performance (Gomero-Fanny et al., 2021).

Singh et al. conducted a survey. The authors questioned the connection between security and Scrum, with this survey. They emphasized that the lack of requirements as well as project management problems are important in software development. It was supported by empirical findings that it should be included in the problem space since this is a significant obstacle to agile software development. It has also been concluded that awareness of such problems can be used to prevent some difficulties in the agile software development process. (Singh et al., 2021).

Zagita et al. presented a study in which businesses incorporated agile methods into their software development architectures. It was emphasized in the study that agile software development comes to the fore in adapting to rapidly changing needs. However, it was

explained in the study that the functional needs of the Security tools that remain in the background are important. It aimed to combine perspectives on integrating information security into agile software development through a Systematic Literature Review from various academic databases. Key findings highlight that security improvements are embedded in all agile software development, supported by expert opinions from project teams with integrated security practices (Zagita, Raharjo, 2023).

Smith et al. deal with a manageable security solution. In the solution presented by the authors, various cyber incident response situations in the software development process were discussed. Feedback obtained during intervention situations was recorded. These results were then evaluated to focus on missing or problematic issues. After all the response time was taken with the security problems and the return to normal has been significantly reduced (Smith et al., 2021).

Poller et al. discussed a different strategy for integrating security ISSUs into software development. In this context, the authors evaluated providing Security-related training to the software development team. It was observed that the trainings were useful in closing security gaps. The negative side of the experimental results was presented as the adoption of a strategy close to change (Poller et al., 2017).

Maier et al. researched Scrum architecture with the Security model. First, security processes were included in an application developed with the Java programming language. Afterwards, an opinion survey was presented about the application with minimized security vulnerabilities. Finally, using the survey results, the authors concluded that the hybrid use of both models was solved at a moderate level (Maier et al., 2017).

McDonald et al. evaluated agile software applications in education-related processes. Some contributions of agility and security to software development were presented in the study. The authors presented in reports that the issue of introducing agility-related processes should be addressed as the first step in software development (McDonald et al.,2016).

Erdogan et al. offered a solution that also includes security for agile software development. The authors created a security test involving agile software development. According to these test results, it was stated that the security vulnerabilities of a web application developed with agile architecture were identified and performed more useful and secure (Erdogan et al., 2010).

The Studies proposed in the literature prove that Scrum strategy and Security situations can be used together. However, there is a clear need to reveal the relationship between Bibliometric Network Analysis and Co-Occurrence Networking. In this study, these keywords in the literature were scanned and various analyses were presented. These analyzes contributed to the solution of problems related to Scrum model and Security issues.

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2. MATERIAL AND METHODS

The Flowchart for Implementing the Secure Scrum Strategy is presented in Figure 1. The process starts with the key components of the Scrum framework. This framework includes the Project Team, Product Owner, Stakeholders, Project Backlog, and Sprint Backlog. The effective security issues such as the Security Development Lifecycle (SDL), Common Criteria (CC), Touch Points (CT), and Comprehensive Lightweight Application Security Process (CLASP) within the Application Security Framework contribute to the design. The Project Team works closely with the Product Owner and Stakeholders to define and prioritize security requirements, ensuring they are seamlessly integrated into the Project Backlog. The Sprint Backlogs are refined with a security-centric approach. Also, The Scrum Meetings involve the team discussing security concerns. The Security Tests are performed at various stages throughout the application design. Thus, the effectiveness of security measures is verified. Operating systems and product architecture are configured in accordance with best security practices, providing a strong defense against potential threats.

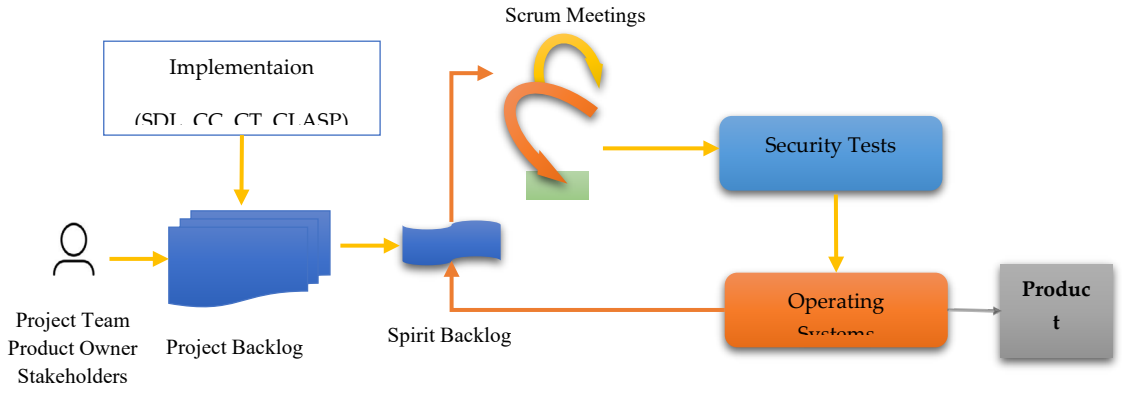

Figure 1: The flow diagram of implementation of secure scrum strategy

2.1. Research Questions

In this study, a statistical and bibliographic research was presented to reinterpret Scrum strategies to include Security concerns. 2 different RQs were focused to conduct the analyzes. According to this, the RQs are as follows:

RQ1. Are security issues addressed in the Scrum strategy?

RQ2. What are the main affecting factors in the successful implementation of security elements in Scrum methodologies?

In the context of these research questions, literature studies in which Scrum strategy and Security issues methods were used together were evaluated. Then, these research data were evaluated with WOS tools and a VOS viewer. Methodologies used to address security concerns through statistical and biographical analysis are discussed.

2.2.Scrum Strategy

The Scrum model is one of the agile software development methods. A Scrum model includes the Project Team, Product Owner, and Stakeholders (Aurisch et al., 2021). On the other hand, the Scrum strategy consists of three stages. These are the planning stage, designing stage, and development stage (Sharma & Bawa 2022). The method provides effective solutions according to the waterfall approach in solving problems such as changing requirements by prioritizing communication and interaction during software development (Rahy & Bass, 2022). In addition, the Scrum method is more effective in solving the needs of developers, the outputs obtained from user experience, and problems that may arise during the release (Kosztyán et al., 2023). The spirits with short development times are preferred. The agile solutions are resilient to changes in requirements are achieved (Chantit & Essebaa, 2021). In this strategy, developers' tasks are designed for short sprint durations. At the end of the period, a planning meeting is held. Backlogs are created at these meetings. So each developer works independently. The unfinished tasks remaining in the Backlog at the end of a sprint are analyzed during the sprint retrospective (Przybyłek et al., 2022).

2.3.Dataset of the study

The dataset of the study was collected from reports obtained using WOS tools. In the research conducted through WOS, the most relevant articles were obtained with the criteria determined by "Scrum", "Agile Software Development" and "Security" keywords. The specific scope was determined with them. The WOS tools are effective for investigating various research and well-indexed topics. Another advantage of WOS tools is that the scope can be limited. For this purpose, four criteria were used in the analysis of the study. These criteria are that the keywords appear in all scanned articles. After all, the Boolean choices are activated and the articles are marked as printed and Engineering subject area. According to the search results using these criteria, the data set of the study was obtained with 53 articles.

3. RESULTS AND DISCUSSIONS

The deficiencies regarding security processes in the Scrum method were eliminated with different suggestions presented in the literature. In this study, where this situation was analyzed, evaluations of the relevant analyses were carried out with the Vos viewer software and WOS tools. For this purpose, metadata of 112 articles were obtained with "Scrum",

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"Security" and "Agile Software Development" keywords. The number of studies was reduced to 53 with scope restrictions. The document exported as a text file contains data regarding as article title, authors, abstract, references, citations, and year. The experimental results obtained from the statistical and bibliographic analyzes made using these data were presented. First of all, it is the distribution of articles according to article publication years. The outputs of this experiment is presented in Figure 2.

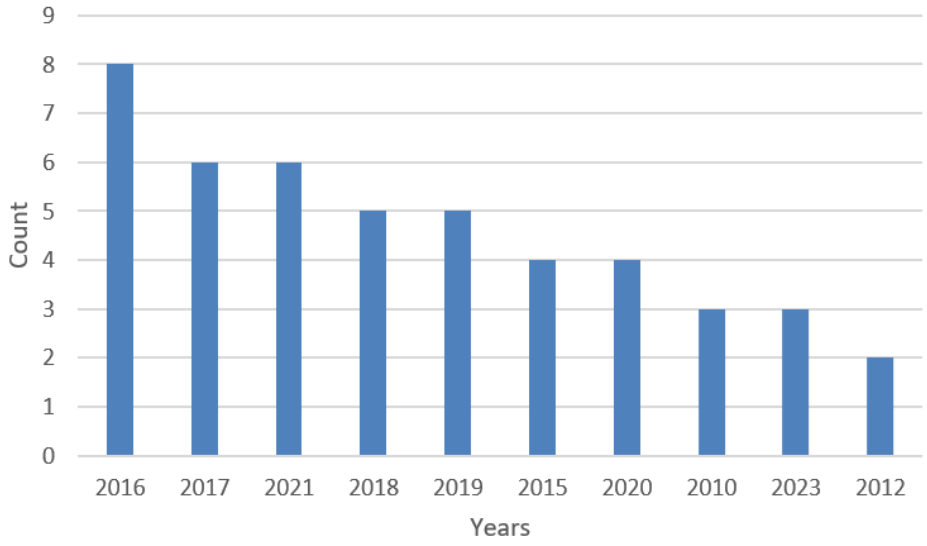

Figure 2: The publication years' report

The terms Scrum and Security are discussed with a general average in agile software development processes in Figure 2. This is an indication that these two development principles will continue to be used together in the future. The results of the analysis conducted on the areas studied regarding Scrum and Security are presented in Figure 3.

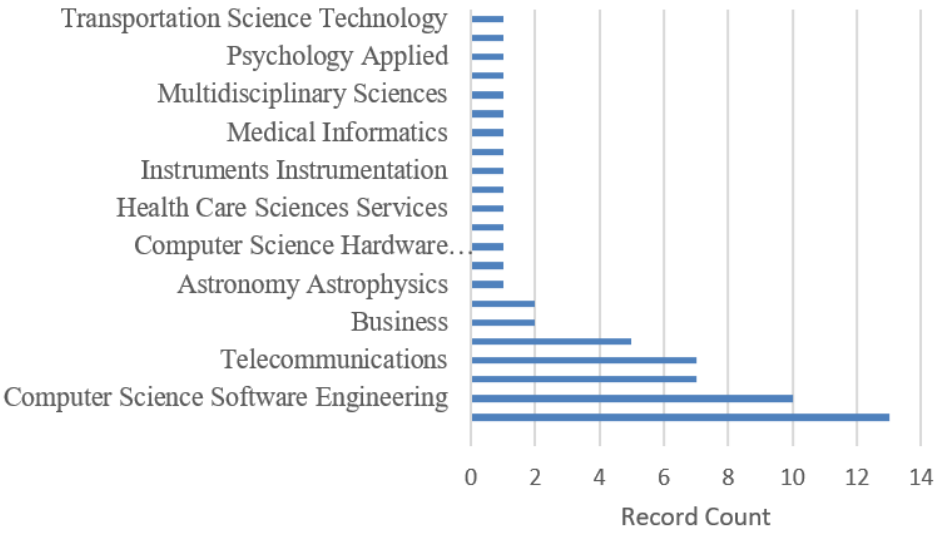

Figure 3: The Web of Science category report

Figure 3 shows various areas where the Scrum strategy is used together with Security. It is obvious that a lot of work has been done, especially in the field of Computer Science Engineering. However, using these two development methods together in different fields shows that there is a cumulative field of study. Studies in the field of business prove that there may be solutions for companies in this field. Additionally, there is a prominent concentration on the Scrum model and security issues.

The results in Figure 4 were obtained in the analysis performed with the Citation Topic. It is obvious that a lot of article were published in the software engineering area. It was also obtained as an output that Scrum and security were handled in different disciplines.

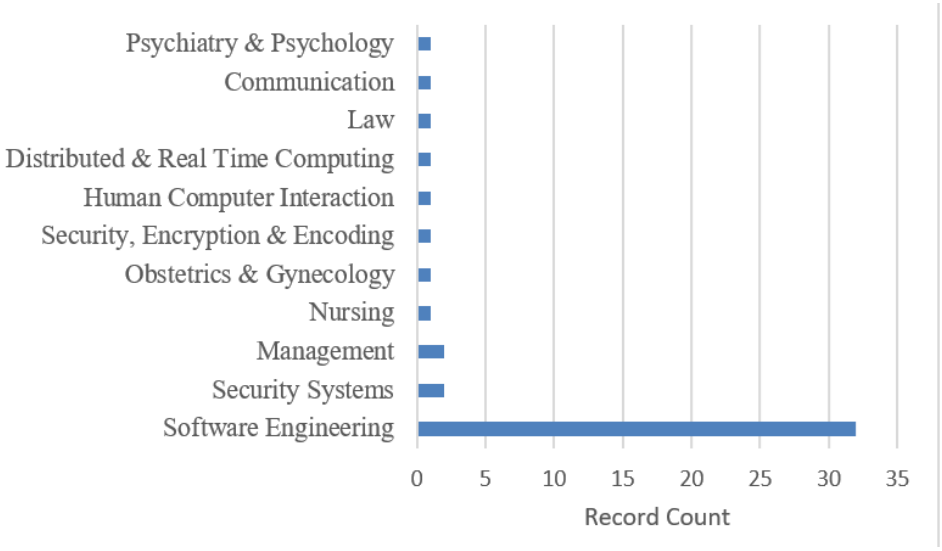

Figure 4: The citations of the report with topic

The WOS Index Report was also included in the analyzes made using WOS tools. These analysis outputs are shown in Figure 5. It seems that conference articles are quite dense compared to articles published in journals. This shows that this field is still a new field of study.

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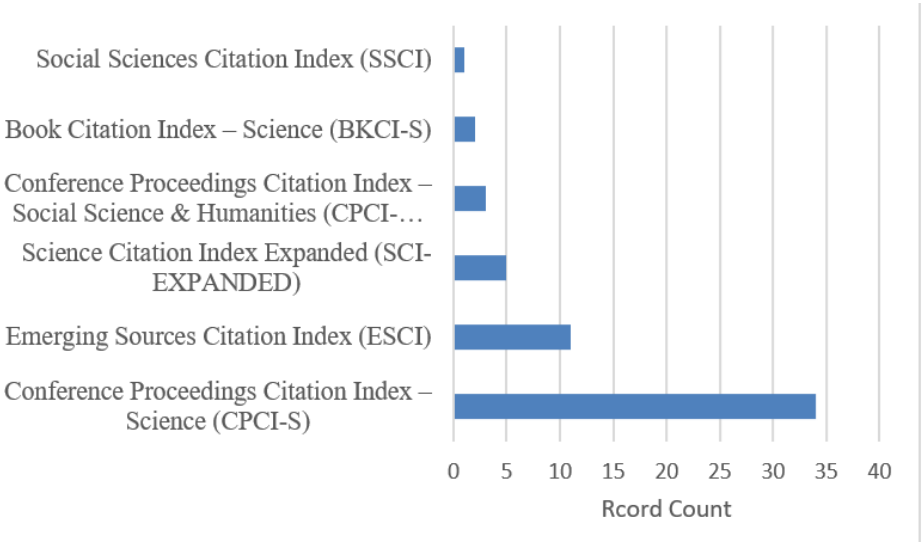

Figure 5: Web of Science Index report

In another analysis, the number of publications in various publication units was evaluated. The results obtained from the analysis of various journal and conference publications are presented in Table 1. It is seen that the majority of publications in the scope include software development and security areas. It can be seen from the data in the table that the field with the most publications is security and software development. A small number of publications were published in conference papers in different research areas. However, it is important to publish publications about scrum and security from conference types in different research fields. The developments performed using these two terms in different fields are an indication of the existence of an interdisciplinary process. In terms of publication diversity, it is obvious that computer science is predominant. It is also possible to infer that publications in this field have continuity.

Metadata obtained with WOS was analyzed with vos viewer. The bibliometric maps were visualized with them. The relationship between Scrum and Security was visualized by creating various node clusters. The detail levels of the clusters were obtained by setting the resolution parameter to default. Cluster analysis was performed including keywords related to these results. The keyword report shows the popularity and citations of research topics. The results obtained from this analysis are presented in Figure 6. It seems that the keywords Scrum and Security have an important place. In addition, node clusters were preferred in these outputs. For clustering, resolution, and minimum cluster size need to be set. These results represent trending research topics and their relevance levels.

Table 1: Published articles in conferences and journals

Conferences-journals	**Articles Amount**

International Journal of Computer Science and Network Security	7
Human Computer Interaction	2
Information Systems and Technologies Conference	2
Information and Communication Technology Conference	2
Agile Development with Integrating User Centered Design	2
11th International Conference on Availability Reliability and Security Ares, 2016	2
1st International Conference on Information Security Privacy, 2015	1
19th Asia Pacific Software Engineering Conference Apsec Vol 1, 2012	1
5th International Conference on Cyber Conflict Cycon, 2013	1
International Conference on Computer Graphics Vision And Information Security ,2015	1
2nd International Conference on Computing Technology and Information Management, 2015	1
International Conference on Computer Science and Engineering, 2017	1
International Conference on Technology Management Operations and Decisions, 2018	1
14th Iberian Conference on Information Systems and Technologies, 2019	1
4th International Conference on Computer Science and Engineering, 2019	1
15th Iberian Conference on Information Systems and Technologies, 2020	1
International Conference on Computational Science and Computational Intelligence, 2021	1
Integrated Communication Navigation and Surveillance Conference, 2023	1
22nd International Conference on Circuits Systems Communications And Computers, 2018	1
3rd Annual International Conference On Computer Games Multimedia Allied Tech., 2010	1
4th International Conference On Innovative Computing	1
9th International Symposium On Digital Forensics And Security, 2021	1
Advanced Education	1
The Proceedings of Agile	1
Software Engineering and Extreme Programming with Agile Processes	1

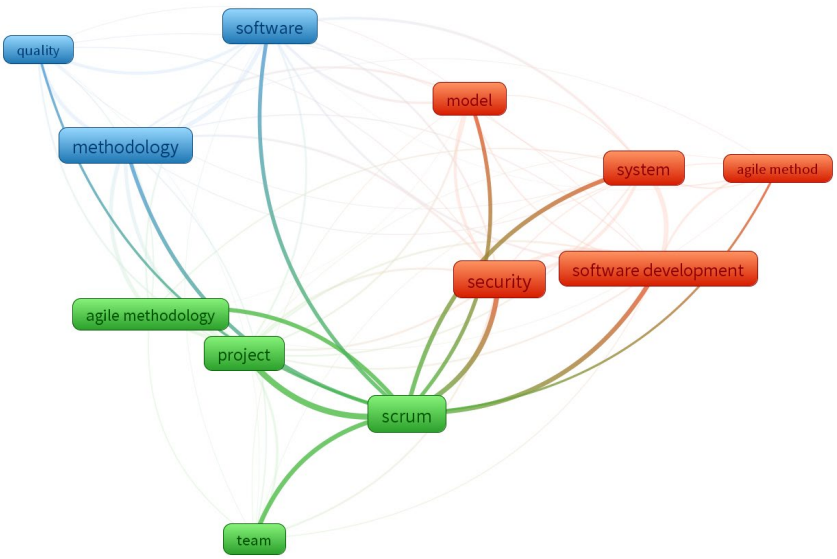

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Figure 6: Keyword report with scrum and security

The analysis result determining the amount of citations according to various fields is presented in Figure 7. In general, it was observed that there were a lot of references to the software field. On the other hand, it was obtained as a result of the analysis that references were obtained from different research fields. This shows that it can receive these references on Scrum and Security not only in the software field but also in different technologies.

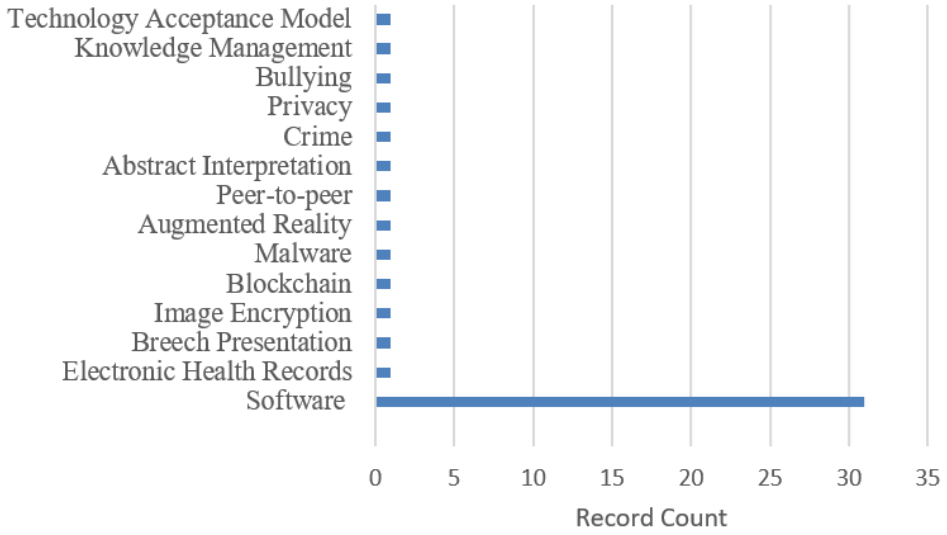

Figure 7: Citation report with scrum and security

The final analysis with Scrum and security is a co-citation report. The outputs of this analysis are presented in Figure 8. A scale from purple to yellow was shown in the output report, in which the density of citations made in this field and the density of them were presented cumulatively. This scale also includes distribution by year. As the year progresses, a spread towards yellow is observed. It can be understood from the figure that the studies carried out in recent years are closer to the center. This proves that the studies tend to have a continuity.

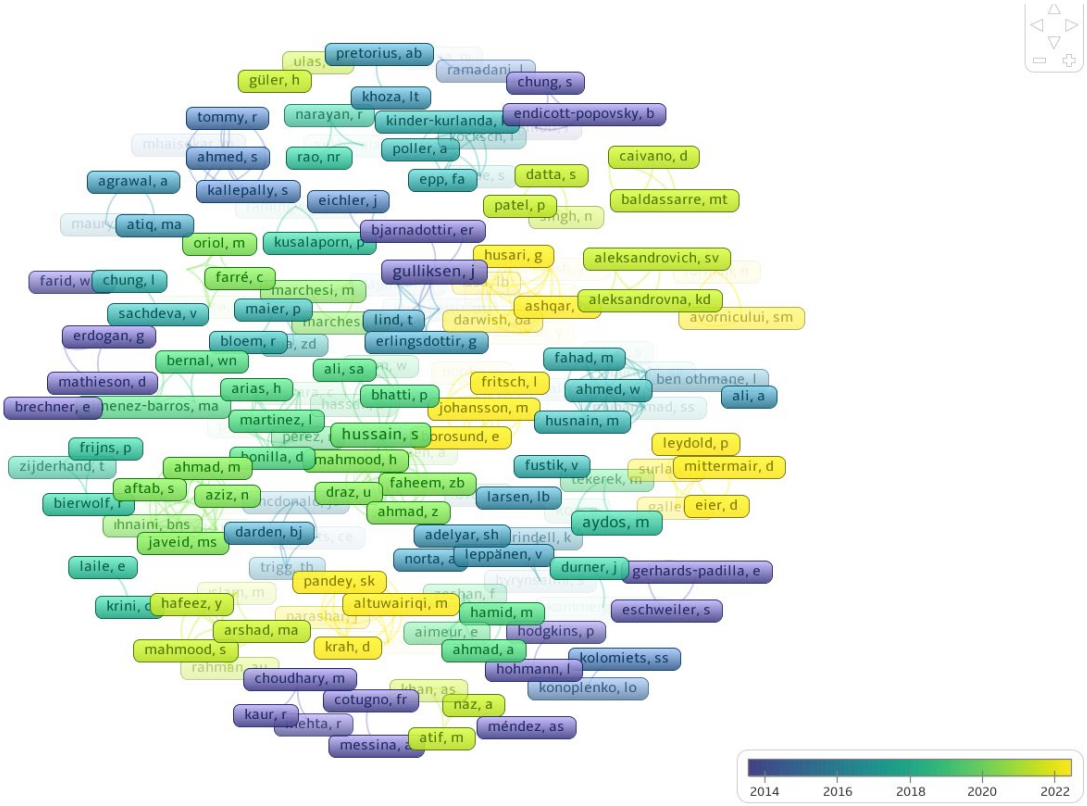

Figure 8: The co-citation report with authors

Especially in recent articles, Security and Scrum models are used together. The necessity of developing secure agile software in accordance with today's conditions is determined by adding security processes to the Scrum flow chart expressed in this study. A study similar to the suggestion made was presented by Nath et al. The authors proposed a scale that classifies source code in software development. With the help of this scale, they presented a score range map that defines vulnerability. The security cases could be included in the agile software process, with this method added to Scrum processes (Nath et al., 2023). Bayram et al., developed the statistical and bibliographic analyses. The authors discussed the published articles on agile software methods. They conducted systematic literature searches using Scopus, WOS, Science Direct, and Xplore. In the analyses, relationships between authors, publications, institutions, references and countries were evaluated. The evaluations were performed with Gephi and Vos Viewer. As a result, the requirements of agile software development were revealed through research questions (Bayram et al., 2022).

4. CONCLUSION

The study presented a statistical and bibliographic analysis of how Scrum strategy and Security requirements are solved in agile software development processes. In these analyses, metadata of articles on eliminating security issues in the Scrum agile model. It was observed that the analysis outputs obtained by processing this metadata could be adapted to Scrum

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methodology and security requirements in different ways. It has been determined that organizing small task parts in Scrum spirits is important, especially in solving problems arising from security issues. In addition, recent studies have shown that a close relationship between them. This link is becoming more accepted in the field of computer science engineering. These results show that security processes should now be included in the Scrum strategy. Incorporating Scrum strategy and security into agile software development will enable the development of a software product that is more robust against security issues.

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