Systematic Literature Review of the spiral development model: Topics, trends, and application areas

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Abstract. The spiral model is one of the methods used to perform software engineering development and can also be used for development in other fields. This spiral model is the result of a modification from the combination of the waterfall model and prototyping model so that it has many advantages including in each result an evaluation will be carried out, carried out sequentially or systematically, and is more focused in carrying out risk analysis from each stage. Has a function in development to make changes, additions and developments by determining accuracy and speed based on needs. In its implementation the spiral model has been carried out in various fields, but the results of the implementation are not yet known in what scope and how many implementations each year. This study aims to identify the results of the implementation of the spiral model development with data obtained from related papers in the 2012-2022 range. The method used in this study is the Systematic Literature Review (SLR) with the aim of identifying, reviewing, evaluating, and concluding all research on each relevant paper. The results showed that the spiral model development was mostly implemented in software development with a total of 19 papers and in the education sector as many as 17 papers, while the peak of the spiral model development was mostly implemented in 2016 and then increased again in 2021.

Keywords: Software Engineering, Spiral Model, SLR

1. Introduction

Software engineering is a discipline that discusses all of the aspects of software production, from the initial stages of system specification to system maintenance [1]. In general, the purpose of this engineering is to produce software that performs high and on time. To achieve this goal, various fields of science form disciplines that will collaborate in producing a product that will be used. This is assisted by the Software Development Life Cycle (SDLC), a set of basic procedures used in the design, development, and testing of software applications [2].

In SDLC, the software development process has different methods. The software development process has similarities with other product manufacturing processes that involve many components and factors. A software product has a good success rate when the

components are well-designed and can be linked together [3]. The waterfall method appears to overcome the complexities that occur in a project. The Prototype method is the part of the product that expresses the logic as well as the physical external interface that is displayed. The Spiral method is a model that focuses on prototyping and risk management which is very flexible when compared to the waterfall method.

The advantages contained in the spiral method, make it more widely used by developers. This spiral method provides a mechanism for quality goals and software integration into product development. A previous literature review concluded that many models develop systems based on client requirements for projects. Several models have advantages and disadvantages, including the waterfall method and the spiral method [3]. Another literature review also discusses the problem of teaching mobile application development with high demand for qualifications. The results of the study show that the spiral model can be used for curriculum development in the field of computer science in teaching mobile device development [4]. Other research discusses the spiral method and the possible application of the method in software development [2]. Using a different method model that is not contained in the SDLC basis but focuses on other factors such as cross-platform, the way users interact in developing mobile-based applications [5].

In the application of the spiral method in software development, there are still many things that can be studied in more depth related to the method. Based on this, this research will reveal areas of application that use the spiral method, then what trends and research topics are discussed using the spiral method. This is expected to provide benefits for finding ideas and research topics in the field of software development using the spiral method.

2. Method

The review method used in this research refers to the B. Kitchenham guidelines for a systematic literature review. The descriptions that will be used are research questions, data sources, inclusion & exclusion, quality assessment, data extraction, and data synthesis.
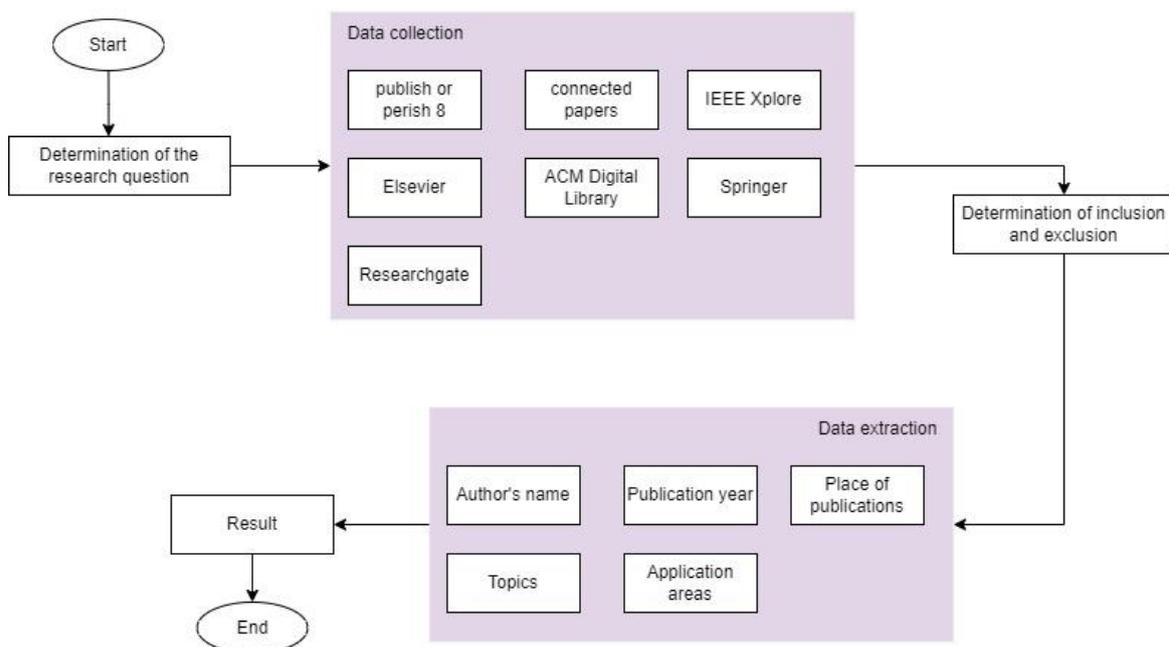

Figure 1. Research methodology

2.1. Research Questions

Defining the research question is the most important part of a systematic review. These questions encourage what will be the focus in solving the problems found. The research questions in this study are as follows:

RQ1. What research topics use the spiral method?

RQ2. Trends in the use of the spiral method in the last 10 years?

RQ3. What fields implement the spiral method?

2.2. Data Sources

Data sources are used to collect certain data, and necessary information, and access data that will be used for certain purposes in a complete data source [5]. In this literature review, the collection of data sources uses the publish or perish 8 application to find papers with specified topics. Then use several websites such as connected papers, IEEE Xplore, Elsevier, ACM Digital Library, Springer, and Researchgate to find indexed papers.

2.3. Inclusion & Exclusion

Inclusion is used to determine the general characteristics of research subjects in the target population and on the topics to be covered. While exclusion is a general characteristic that cannot be included in the target population and on the topics to be covered [6]. The results of inclusion and exclusion carried out were 71 papers. The following are the inclusions and exclusions in this literature review:

a. Inclusion = the reviewed paper must be in full text with a publishing time of the last 10 years, namely 2012 to 2022.
b. Exclusion = does not deviate from the inclusion criteria that have been set.

2.4. Data Extraction

The data extraction procedure has been developed by the authors taking into account the purpose and the important nature of the data to be reviewed. There are five points of data extraction that will be carried out as follows:

a. Author
b. Publish year
c. Place of publication
d. Topics
e. Field of application

2.5. Data Synthesis

This process is the conclusion of the answer to the research question from the data that has been collected. At this stage, it will be used to analyze the literature statistically.

3. Results and Discussion

Just like a spiral shape in general, which represents the software development process by tracing from the middle point to the outside like a spiral. This method is classified as an old method developed by Boehm in 1988 with the strands of each spiral being a phase of the software development process. Thus, each strand defines system requirements, system design, and so on as shown in figure 2 [6]
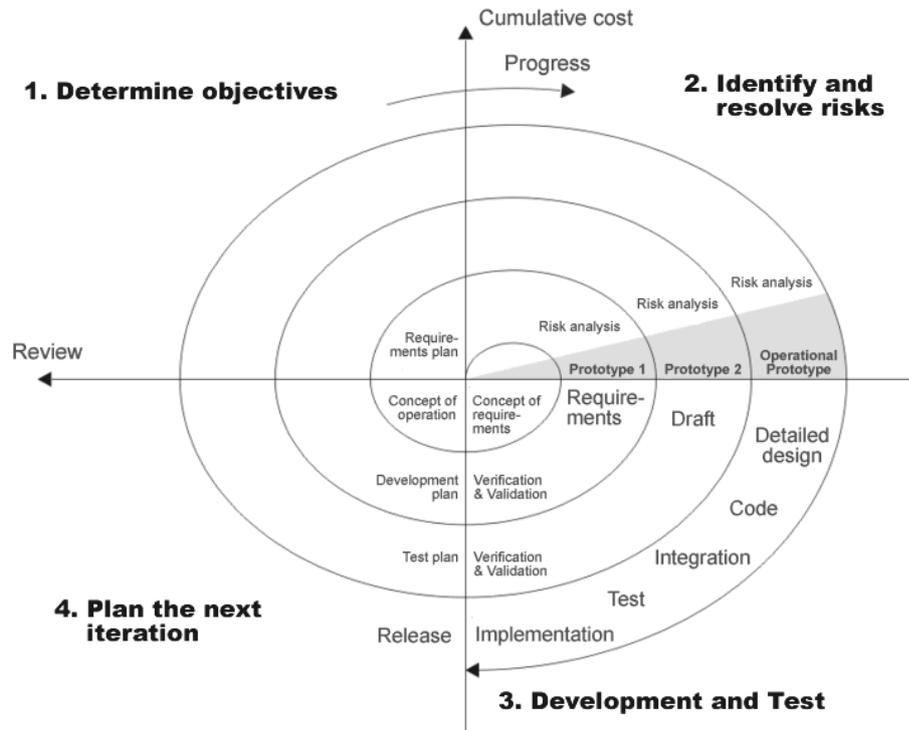
Figure 2. Spiral Model

The important difference that exists between the spiral method with other software development methods lies in the consideration of risk in developing software, where software development using the spiral method is carried out with explicit risk considerations. In the spiral method, risk considerations are explicitly explained by using pictures that each process passes through the stages of risk analysis.

Software developers do not directly produce a design until the end of the system, but gradually according to the method used. This design is intended to find out the mistakes and shortcomings of early development. The developers also adjust to the topic or idea that the user wants and in what field the application of the software is. Therefore, this literature will describe the topics that are popularly used for software development using the spiral method and also the field of application based on the results of research conducted by researchers in the last 10 years.

The results of data extraction as many as 71 literatures collected in the last 10 years are shown in table 1. The review carried out on the reviewed literature is as follows:

a. Does the literature refer to the specified research question?
b. Year of publication
c. Place of publication
d. Topics
e. Field of application that uses the spiral model in the literature

Table 1. Literature Spiral Model

Paper Title	Year	Publication	Topics	Scope
[7]	2012	Indian Stream Research Journal	Risk management in software development	Software development
[8]	2012	INTERNATIONAL CONFERENCE ON EURASIAN ECONOMIES	The methodology is analyzed from an economic perspective with respect to the cost model	Economic analysis
[9]	2012	IEEE	Identification, measurement, evaluation and promotion to more effectively leverage customer knowledge and enhance their service innovation capabilities	sales business
[10]	2012	IEEE	Integrating usability into the application development process and recommending usability techniques for assessing mobile applications	Software development
[11]	2012	International Journal of Applied Information Systems	IT governance criteria, technical aspects, and managerial aspects that provide a robust approach to the systems development process	Software engineering
[12]	2012	CIRP Journal of Manufacturing Science and Technology	Understand what are the characteristics and structure and sequence of phases that characterize a well-done Product-Service System (PSS) engineering	sales business
[13]	2012	Journal of pengembangan perangkat lunak	Implementation of software development with a concern for security	Software development
[10]	2012	2012 Seventh International Conference on Computer Engineering & Systems (ICCES)	Mobile development designed to integrate usability into existing application development processes	Software development
[14]	2013	International Journal of Information Management	Help organizations realize where to implement security measures to reduce vulnerabilities in software applications	Software application
[15]	2013	International Journal of pengembangan perangkat lunak and its Applications	Reduce the impact of most of the risks by using the proposed reengineering through getting all the useful features	Software engineering
[14]	2013	International Journal of Information Management	Identification of security vulnerabilities in software development	Software development

Paper Title	Year	Publication	Topics	Scope
[16]	2013	Advanced Materials Research	Reduce the risk of highway landscape planning, and is also conducive to the establishment of defined planning requirements	Civil Engineering
[17]	2013	PARIDNYA	Implementation of security management for IT security infrastructure	IT Infrastructure Security development
[18]	2014	IPASJ International Journal of Computer Science (IIJCS)	Website-based software development	Software development
[19]	2015	International Journal of Science, Technology and Society	Designing an Advanced Transportation Management System (ATMS) with the development of digital image processing	Software development
[20]	2015	elsevier	Fulfilling the goal of developing Business intelligence	Business Environment
[21]	2015	elsevier	Different frameworks for leveraging big data in public governance	Government
[22]	2015	Jurnal Rekayasa Sistem & Industri	The warehouse function at Waroenk Laundry is well and precisely documented so that it can overcome existing problems	Sales business
[23]	2015	National Conference On Advance Trends In Computer Science & Mathematical Technique	The mobile application focuses on cross-platform development factors, memory usage, interaction with users and the proposed MADLC model.	Software development
[24]	2015	ICSSP 2015: Proceedings of the 2015 International	Introducing ICSM as a means to address the need for more flexible and responsive systems engineering	Software development
[25]	2016	JMIR	Designing a mobile-based Mo-Buzz application for dengue fever	Health
[26]	2016	researchgate	Build an i-brochure application based on mobile augmented reality	Education
[27]	2016	Elsevier	Building a framework to provide a suggestion	Development Project
[28]	2016	Springer	Efficient software error prediction and classification using naive bayes	Software development

Paper Title	Year	Publication	Topics	Scope
[29]	2016	International Journal of Computer & Organization Trends (IJCOT)	Create and evaluate better ERP software	Software development
[30]	2016	SIMETRIS : JURNAL TEKNIK MESIN, ELEKTRO DAN ILMU KOMPUTER	Provide a report on research results regarding the implementation of the a priori algorithm	Sale
[31]	2016	Jurnal Masyarakat Informatika	Building a website-based e-commerce with a fairly high level of development complexity	e-commerce
[32]	2016	Konferensi Nasional Sistem & Informasi	Designing a forum for discussion between customers into e-commerce	e-commerce
[33]	2016	2016 IEEE 8th International Conference on Technology for Education	Software testing among computer science and engineering engineering degree program students as a solution to the previous curriculum	Education
[34]	2016	Jurnal Sistem Informasi (JSI)	Online reservation and control system for Purwodadi Botanical Gardens.	Software development
[35]	2016	IJPE	Knowledge management is used to achieve quality in finished products	Software development
[36]	2016	IJCOT	Software in model selection to save time and provide customer satisfaction	Software development
[37]	2017	elsevier	Using the Bayesian method to model problems regarding rhino hunting.	Rhino hunting
[38]	2017	Bioedusiana: Jurnal Pendidikan Biologi	Knowing the improvement of student learning outcomes by using cooperative learning model type student teams achievement divisions	Education
[39]	2017	CogITo Smart Journal	Help visitors in finding rooms, shops / tenants in Mantos with a 3D view	Software development
[40]	2017	Jurnal Ilmiah Matrik	Utilizing GIS (Geographic Information System) for mapping regional assets	Government
[41]	2017	Cogito Smart Journa	Augmented Reality technology in developing learning aids applications, stimulating thoughts, feelings, attention	Education

Paper Title	Year	Publication	Topics	Scope
[42]	2017	International Journal of Intelligent Engineering and Systems	Test the software at each SDP cycle, based on a measure of feature similarity in the dataset	Software engineering
[43]	2017	Security in Computing and Communications	Software development, which consists of risk analysis factors also to provide flexibility	Forensics
[44]	2017	Methods in Ecology and Evolution	describes the stages of the modeling process that lead to positive changes in collaboration with stakeholders	scientists, ecologists and environmental management
[45]	2018	CogITo Smart Journal	Information on tourist objects in Tomohon City in the form of 360o Panoramic Photos	Tourist
[46]	2018	JATIKOM	Design and develop a meeting attendance recording system	Education
[47]	2018	Cogito Smart Journal	Changing manual bell system to automatic bell system	Education
[48]	2018	Jurnal Ilmiah SISFOTENIKA	Make a bible application using talaud language that has a dictionary feature, word search, and also article search	Religious
[49]	2019	Education and Information Technologies	Train in mobile application development with the aim of effective training for developers	Education
[50]	2019	Ecological Informatics	management of socio-ecological systems to improve communication, trust, and stakeholder participation	Management of socio-ecological systems
[51]	2019	International Journal of Advanced Computer Science and Applications	Implementation is easier to implement and conforms to CMMI specifications without hiring external experts	Software development
[52]	2020	Jurnal Pembangunan Pendidikan: Fondasi dan Aplikasi	Knowing the increase in students' learning creativity in thematic learning using the Project-Based Learning (PBL) approach	Education
[53]	2020	INDEX	Web-based production scheduling system	Company
[54]	2020	JICON	Drug management information system in hospital pharmacies	Health

Paper Title	Year	Publication	Topics	Scope
[55]	2020	JINTEKS	Designing and building a child development monitoring system in IT Kindergarten	Education
[56]	2020	Rural Sustainability Research	Innovative industrial development mechanisms (in the example of the Republic of Belarus and the Russian Federation)	Innovative industry
[57]	2020	CISIM 2020: Computer Information Systems and Industrial Management	A framework for developing software solutions with a Service-Oriented Architecture (SOA) applied for biological image analysis	biological and medical image
[58]	2021	JISICOM	Learning that innovates and develops to improve performance in the teaching and learning process through the e-learning system	Education
[59]	2021	Jurnal Teknologi Sistem Informasi dan Aplikasi	Development of a web-based car rental information system	Item rental
[60]	2021	ILKOMNIKA	Moodle-based e-learning development	Education
[61]	2021	The IJICS (International Journal of Informatics and Computer Science)	Ferry cruise scheduler information system	marine
[62]	2021	PARADIGMA	PPDB information system to overcome student admission problems	Education
[63]	2021	Jurnal SIFO Mikroskil	Information system to make it easier to report results from the color shop	Sale
[64]	2021	International Journal of Computer-Supported Collaborative Learning	Collaborative knowledge enhancement for multi-layered CSCL process scaffolds and structures	Education
[65]	2021	JURISMA, Jurnal Sistem Informasi dan Manajemen	Design and build an administration system produced by PT Muramoto Elektronika Indonesia	Sales business
[66]	2021	BMC	EBM-based OSCE evaluation and development to assist in the assessment of medical students	Health

Paper Title	Year	Publication	Topics	Scope
[67]	2021	journal of Economics and Administrative Sciences	Increase opportunities for organizations to successfully undertake BPR projects, actions and initiatives	Software development
[68]	2022	Jurnal Ilmu Pendidikan	Venn diagram application development based on android	Education
[69]	2022	Journal of Computing Engineering, System and Science	The plant marketplace in the form of an android application	SMEs in the field of plants
[70]	2022	Jurnal Informasi dan Komputer	Web-based online school library system	Education
[71]	2022	Jurnal MNEMONIC	Information system of Sumbawa University of Technology facilities and infrastructure in software development	Education
[72]	2022	Remik: Riset dan E-Jurnal Manajemen Informatika Komputer	This information system can be used properly by the USU Department of Anatomical Pathology to improve the quality of laboratory services	Education
[73]	2022	Journal of Computer System and Informatics (JoSYC)	The Mei-V application for recording equipment maintenance can be done by connecting directly to the database	Software development
[74]	2022	Engineering Applications of Artificial Intelligence	Algorithm optimization based on Arithmetic Optimization Algorithm (AOA), namely OSAOA to improve optimization performance	Software engineering
[75]	2022	International Journal of Emerging Technology and Advanced Engineering	Comparative analysis in software development	Software development

Based on the results of data extraction in table 1, the next section answers the research question from the research that has been determined.

3.1. RQ1. What research topics use the spiral method?

Table 2 shows that the various topics from each literature. To make it easier to review the topics discussed, we make a grouping of each literature that is included in the topic of discussion. The result is that from the 71 literatures collected, they fall into 3 categories, namely websites, mobile and information systems.

Table 2. topics used in the spiral method

No	Topics	Number of Literature
1	Website	11
2	Mobile	7
3	information systems	53

The website was found to be the first topic of discussion. A website is a series of web pages that contain related topics, and may be accompanied by image, video, or other files. Various methods can be applied to website creation applications, one of which is the spiral method, which can save creation costs and increase the efficiency, flexibility and agility of website design [18].The development of spiral methods in e-commerce helps us to get feedback from customers in the form of suggestions, criticisms or input to e-commerce so that the applications created can meet the needs of all customers [31]. In the field of education, it can be developed to improve performance and information in the teaching and learning process through a website-based e-learning system [58]and the creation of an online school library system based on a website that everyone can read [70].

The next topic is mobile. Mobile is software that runs on mobile devices such as smartphones and tablet PCs. Mobile phones are known as downloadable applications and have special features that complement the capabilities of the mobile device itself. There are several models that can be developed on the Android operating system. One of them is a spiral model. This model can be used to create software that requires a roadmap to identify risks and plan testing activities so that they can be better evaluated [29]. Spiral model development covers all levels of programming with the aim of developing knowledge from programming to program development [49]. English translation. The use of spiral models can be used in mobile-based meeting attendance recording systems [46]. When designing a 3D view, such as creating a 3D model of a building, it can be created using the Google Sketchup 3D modeling application, which serves as a scene within the application [39]. In research [48] The spiral model was used to implement the Talaud language Bible application. The app is built using the Edrawmax tool, Eclipse and Android SDK SQLite.

The next most popular topic to discuss is information systems. An information system is an organized way to collect, input, process, and store data, and a set of methods for storing, managing, controlling, and reporting information so that an organization can achieve its established goals, is also an organized way. An information system is a collection of interrelated and complementary data that achieves good results, solves existing problems, and makes decisions[62].

This spiral model is divided into six activity frameworks called task areas. In other words, communicating with customers is the first thing you do to establish communication between developers and customers. The purpose of planning is to plan the resources to be used, the estimated time, and other information necessary for the project, risks. Analysis aims to consider possible risks, and engineering aims to make one or more representations of the applications made [60], to understand which are the main characteristics (how) and the structure and sequence of phases (what order) characterize the engineering process [12]. The spiral model allows researchers to carry out repetitive processes but with a more developed stage than the process that has been passed before, so that researchers can understand the risks that occur and handle those risks (risk management) [45], to describe the planning of dynamic processes, and realize the dynamic concept of planning, consequently, effectively to

reduce the risks that occur [16] and The software development spiral model, which consists of risk analysis elements, also offers flexibility that addresses all the weaknesses of the previous methodology [43].

With spiral models, most risks can be reduced by retaining all the useful features of spiral models with recommended refactoring. [15] and The spiral model is consistent with an approach that includes multiple software builds and allows for an orderly transition to maintenance activities [7]. Spiral models can be implemented for IT infrastructure security [17] and security protects software products from deployment [14]. Implement the security development phase in a spiral model and propose new security [13].

3.2. RQ2. Trends in the use of the spiral method in the last 10 years?
The trend of publications towards software development studies using a spiral model is presented in Figure 3 with the amount of literature used is 71 literatures from 2012 to 2022. It can be seen that the peak of publication of studies on software development using spirals was in 2016 and decreased 4 years later and peaked back in 2021.
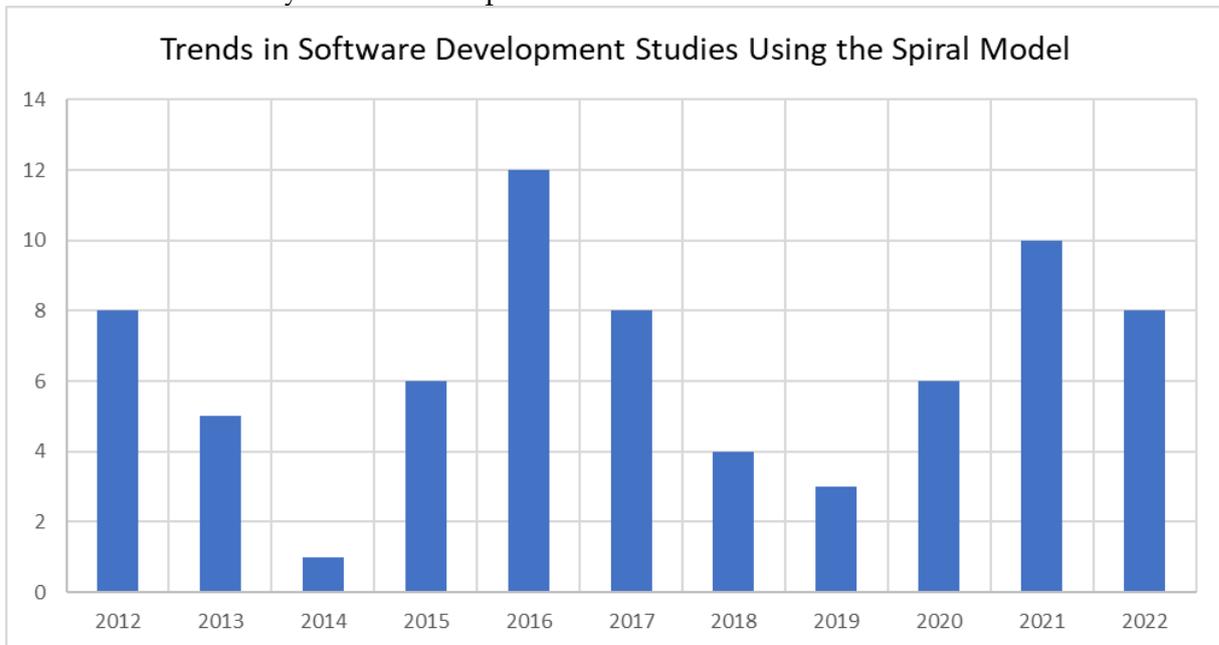

Figure 3. Trends spiral model

3.3. What fields implement the spiral method?
Researchers conduct research in developing a software using the spiral method, the most contributing to the field of research which can be seen in the following table 3.

Table 3.

No	Fields Implement	Quantity of Literature
1	Economic analysis	1
2	Software application	1
3	Biological and medical image	1
4	Sales business	4

No	Fields Implement	Quantity of Literature
5	e-commerce	2
6	Forensics	1
7	Scientists, ecologists and environmental management	1
8	Innovative industry	1
9	IT Infrastructure Security development	1
10	Religious	1
11	Marine	1
12	Health	3
13	Business Environment	1
14	Tourism	1
15	Government	2
16	Education	17
17	Management of socio-ecological systems	1
18	Software development	19
19	Sale	2
20	Item rental	1
21	Rhino hunting	1
22	Company	1
23	Development Project	1
24	Software engineering	4
25	Civil Engineering	2
26	SMEs in the field of plants	1

Research on the application of software development is mostly done by researchers in applying the spiral method with 19 research papers out of 71 reviewed papers. Then there are also 17 papers that discuss the application of the spiral method in the field of education.

4. Conclusion

This section discusses the research questions and identifies each of the questions that have been determined in this research. In 2012 to 2022, there are 71 literatures which are then grouped into 3 categories, namely websites, mobile and information systems. The number is shown in the Table 2 with research topics discussing information systems being the research topics that were most widely raised by researchers with a total of 53 studies, compared to website and mobile research topics which had 7 on website topics and 11 on mobile topics. The peak of publication of studies on software development using the spiral method was in 2016 and decreased 4 years later and peaked again in 2021. The Table 3 shows which fields

apply the spiral method in developing software. The field of application of software development is mostly done by researchers in applying the spiral method with a total of 19 research papers from 71 literatures. Then there are also 17 papers that discuss the application of the spiral method in the field of education. It is hoped that in the future this systematic literature review can provide information and insight, and can provide ideas or ideas for other researchers in building software using the spiral method.

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