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Plan-Do-Check-Action (PDCA) Bibliometric Analysis to Improve Quality

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Abstract. The purpose of this study is to examine or map the growth of research publications on the use of PDCA to improve quality and examine PDCA implementation networks. In this VUCA era and global competition, companies are required to be agile in dealing with any changes and problems that occur. PDCA is used as an effective method of solving problems, one of which is repair or quality improvement. This study uses bibliography data in the Google Scholar database with a research period of 2018-2022. This data analysis uses VOSviewer software as a medium for bibliometric analysis. The results of this study indicate that research has increased every year. Developmental mapping based on co-authorship shows a correlation between researchers, while based on co-occurrence indicates a relationship between concepts grouped into 6 clusters. Density visualization describes stretch so there is an opportunity to do research with that topic or keyword. This research is expected to contribute to the use of the PDCA method to make companies more efficient, effective, and sustainable in controlling the production process.
Keywords: PDCA, Quality, VUCA, VOSviewer.

I. Introduction

The environment in which companies function has changed along with the rest of the world. The current state of change is one of VUCA (Volatility, Uncertainty, Complexity, and Ambiguity), which is a result of technology or digital revolution. PWC (2022) conducted a global risk survey, and the findings show that many CEOs must swiftly modify and adjust their operational models in this chaotic business climate. They are aware that quick thinking is necessary to seize opportunities and prevent danger.

This condition, which is full of uncertainties, requires sufficient information to anticipate changes. Companies must seek as much information as possible to gather new information and insights, especially about competitor information and business positioning. One of the efficient methods for dealing with complexity, such as re-evaluating organizational structure, and rearranging portfolios and finances. Companies must modify all of their operational procedures to account for changing and unpredictable external conditions. The company's adaptability and flexibility in dealing with ambiguous conditions can help companies to survive, accept and embrace these changes as part of the work environment.

In addition to VUCA, the rapid and continuous development of business in the era of globalization requires business people to do everything in their power to survive and win the competition, one of which is in the industrial world. According to Dermawan et al (2023), the marketing era 4.0 is called the Human Centric Era plus digital because marketing 4.0 utilizes connectivity between machines and human intelligence to increase marketing productivity as well as increase connectivity between people so that customer involvement becomes strong. This era is consumer-centric, where consumers demand a more collaborative, cultural, and spiritual approach to marketing. Several changes are so fast that companies need to consider several aspects and things that the company will need in the future.

Organizational risk management and broader survivability must fast change to support business agility and give proactive, robust, and timely risk insights for decision-making in order to deal with the VUCA era and the globalization period. Strong risk management skills and resilience might be advantageous in a changing environment. By taking into account the current dangers, business executives can choose the best course of action while deciding on their plan. A significant risk management challenge, according to 79% of respondents, is keeping up with digital and other transformations (PWC, 2022).

Companies are required to recognize several factors that can threaten the company's performance and develop strategies to overcome them immediately. This is important to maintain business continuity (corporate sustainability). To maintain business continuity, companies need different strategies. Companies are required to have agility or agility to deal with very fast changes, namely the ability to change directions precisely and quickly while maintaining balance. To keep up with the times without losing their original identity, companies must be able to adjust their mindset and way of working. Business people need a method to achieve these goals.

One method that can be used to solve problems and continuous improvement is to use the PDCA (Plan, Do, Check, Action) method which contains 8 steps and seven tools in it. The concept of the PDCA cycle is called the "Shewhart Cycle" because it was first introduced by Walter Shewhart in 1930. Dr. Walter Edwards Deming developed this concept which became known as "The Deming Wheel" (Astutik, 2022). The PDCA cycle is useful as a work pattern in process or system improvement. The PDCA method is a well-known and commonly applied method as a tool for quality control, according to Vargas et al (2023: 3). With this approach, improvements can be made quickly, incrementally, continuously, and effectively at the organizational level without needing to make substantial capital investments.

"Deming proposed it as a systematic and recursive way to develop, implement, monitor, evaluate, and, when necessary, change the course of action. Although Deming's focus is on improving product and process quality, his ideas can be applied to any decision-making activity. The PDCA cycle can frame strategic and operational roles for management accounting information" (Atkinson et al., 2012:6).

According to Atkinson et al. (2012: 6), the "Plan" is the first PDCA stage and it selects the emphasis and breadth of the strategy as well as the organization's goals. Many companies start the planning stage by restating or updating their mission statement, which should provide a clear message to both internal and external stakeholders about the organization's goals and the value it seeks to add to society. Implementing the selected action is what the "Do" phase entails. In this instance, management accounting data is disseminated to the front lines and helps staff members make decisions and carry out everyday tasks. Measuring and monitoring ongoing performance as well as taking immediate action in response to the performance being measured make up the "Check" step. Managers take measures to lower costs, alter resource allocations, enhance quality, cycle times, and process flexibility, alter product mix, alter customer connections, and develop and introduce new products during the PDCA process' last stage, "Action.".

According to Suprihatin (2022), "the PDCA cycle is a systematic way to gain knowledge about processes in an organization or institution and add knowledge to implement quality changes and how to measure them. The benefits of the PDCA Cycle are (1) for the convenience of mapping the authority and responsibility of organizational units, (2) as a work pattern in improving a process or system of an organization, (3) for solving and controlling problems in a sequential and systematic pattern, (4) for continuous improvement activities to shorten workflow, and (5) eliminate waste in the workplace and increase productivity".

Research conducted by Zanuarizqi (2021), PDCA is used to determine standardization of products and processes. This statement is supported by research that examines the application of PDCA to improve quality. Kartika (2020) concluded that after improvements with the application of PDCA, it could increase productivity quite significantly, namely by 71% to 80.6%. Prasetyawati et al (2021), after repairs it was found that the volume of reject clumping is now 0.96% according to company standards and the time needed is 45 minutes. Fatah & Al-Faritsy (2021), quality control using the PDCA method with the seven tools in refrigerator production at PT. X can minimize defects by 22.95%.

In addition to research on the application of PDCA, research on bibliometric analysis has been carried out. Saputri's research (2021) examines the application of a balanced scorecard in various fields of knowledge and business and an organization. Farikhoh and Chariri (2022) conducted a systematic analysis and mapping of the primary research streams, research developments, and directions for future research in the study of corruption. For the purposes of classification, Wilandari (2021) divides both articles and journals into categories based on research themes, categories based on research methodologies, and categories based on the year of publication.

Based on the several studies above that the PDCA method affects quality improvement, the researcher wants to provide an overview of past, present, and future research directions. This research has a novelty from previous studies, namely mapping with the topic of improving quality to see the ability or success of the PDCA method in companies. After that, carry out a bibliometric analysis, as suggested by research conducted by Saputri (2021) suggesting using data testing software with a more up-to-date approach. This motivated researchers to do mapping using bibliometric analysis to see trends and patterns in the development of publications using VOSviewer software. The goal of this study is to map and assess the progression of the literature on the use of PDCA to systematically enhance quality. This analysis identifies gaps and suggests additional research.

II. Literature Review

Expectancy Theory

Expectancy theory is also called valence or instrumentalist theory (Lubis, 2009:89). This theory was first put forward by Victor Vroom explaining that the forces that tend to act in a certain way depend on the strength of the expectations about the results that will be given and see what is interesting (Robbins, 2006: 238). According to Robbins & Judge (2008:254), there are three assumptions about this theory:

1. Expectancy of results (outcome expectancy), namely results will be achieved with the presence of certain treatment from someone who expects these results.
2. Valence, namely there is value that people will give to the expected results because each result or achievement has value for the individual.
3. Effort expectancy, namely there is effort from someone in achieving a certain result because each achievement is related to how difficult it is to achieve it.

Expectancy Theory is based on expectations (expectancy), value (valence), and linkage (instrumentality). Therefore, the expectations theory in this study is advantageous to people who seek to maximize satisfaction while mapping PDCA to increase quality.

PDCA (Plan, Do, Check, Action)

According to Khaerudin and Rahmatullah (2020), Deming gave birth to the Deming cycle (Deming Cycle/Deming Wheel) where quality can be controlled through a continuous and continuous process through the application of PDCA (Plan–Do–Check–Action). This cycle is used to implement production process performance improvements in a company:

1. Plan is an activity to plan, set quality standards, and develop specific quality control continuously and continuously.
2. 2. Do is an activity of implementing and controlling the plan in stages so that the target can be achieved.
3. 3. Check is a checking activity, that examines the results achieved by comparing the standards that have been set so that the implementation is following the predetermined plan.
4. 4. Action is an activity of carrying out adjustment actions as necessary as a result of the check stage. This action is divided into Corrective Action which is a solution to the problems encountered and Standardization Action which is a standardized method.

The PDCA Cycle method is a kaizen tool that can be implemented to achieve continuous improvement (Kusumawardani et al, 2021). The application of continuous improvement can be carried out using the PDCA cycle which consists of strategic planning, implementation, checking of planning results and evaluating the results that have been obtained. This cycle is considered to make it easier for companies to carry out continuous improvement (Ardyanfitri & Izaak, 2023).

Quality

A product or service's quality is determined by its capacity to satisfy customers. Quality serves primarily as a desirable characteristic to increase the value of a product (Astutik et al., 2022). Building an effective differentiated, low-cost, and quick response plan can be aided by quality management. The caliber of the goods and services produced is the primary determinant of a company's performance. According to Aghivirwiati et al. (2022:1), high-quality goods and services are those that satisfy customer needs. Product quality is defined as a product's capacity to carry out its intended functions, which includes overall robustness, dependability, correctness, ease of use, and product maintenance (Philip & Amstrong, 2014: 337). Increasing consumer knowledge about product quality requires producers to carry out quality control of the quality of the products produced. Therefore, producers try to produce quality products as a service to consumers. Improvements in quality control must be carried out through a continuous and continuous process (Utami & Djamal, 2018).

VUCA (Volatility, Uncertainty, Complexity, Similarity)

Social scientists at the U.S. Army War College coined the acronym VUCA (Volatility, Uncertainty, Complexity, Ambiguity) in 1987 to represent the erratic geopolitical circumstances that followed the end of the cold war. The abbreviation VUCA was frequently used to describe the quickly evolving business environment after the fourth industrial revolution. VUCA refers to the idea of unpredictable business situations and how businesses or business organizations can deal with them. This means a) Volatility: the dynamics of very rapid change in various matters such as social,

economic, and political. b) Uncertainty: because it is difficult to predict issues and events that are happening. c) Complexity: this is a very complex situation because many things are very difficult to solve. d) Ambiguity: a situation that feels floating and its clarity is still questionable (Hantono, 2022).

The VUCA concept is changing the way companies or business organizations make decisions, manage risk, drive change, and solve problems. VUCA describes a situation of constant and unpredictable change that now seems to have become commonplace in the business world. Events that occur outside the organizational environment can have positive or negative impacts (Murugan et al., 2021).

Globalization

The era of globalization is an era or era where all human activities are related to technology, in this era there are many developments, especially in the field of technology. For example, at this time in human life and its functions must be associated with technology and technology as a tool that is useful in the functioning of humans themselves. Therefore, over time the competition will get higher and people in this era are competing to use existing facilities to achieve more goals. The situation of companies in the current era of globalization is faced with intense competition, this is due to the emergence of companies both in the manufacturing and service sectors. So that in this era of globalization requires companies to develop productive steps to survive in the face of competitive conditions (Tanjung et al, 2022). This encourages companies to be more efficient and selective in running their business, and each company is expected to be able to manage the company to be more professionally so that companies can achieve high and long-term profits (Azizah et al, 2023). Globalization is a concept that is very commonly used to characterize the current state of the world economy but is understood differently by characterizing it as a phenomenon (Burlacu et al, 2018).

Sustainability

"The principle of sustainability (sustainability) in every corner of the business is expected to drive the company's growth. Sustainability is the impact where the actions taken at this time are the same as the choices available in the future. Corporate Sustainability relates to the company's ability to create profits, the company's ability to protect the environment, and the company's ability to improve social life. According to Supriyadi, Corporate Sustainability is divided into three dimensions, namely economic sustainability, environmental sustainability, and social sustainability" (Aribowo, 2018). Business continuity can be said to be a situation or business condition of an organization that allows for the development and protection of resources while meeting the needs of the organization (industry). Sustainability involves the integration of three main dimensions, namely economic, environmental, and social, which are often referred to as the "Three Pillars of Sustainability" or the "Triple Bottom Line" (Wardhono, 2012). The concept includes efforts to maintain a balance between meeting current needs without compromising the ability of future generations to meet their own needs. This concept is based on the principle that natural resources, the environment, and human society must be managed wisely to survive in the long term (Utami et al, 2023).

Bibliometric

Bibliometric analysis is one of the most straightforward and intelligent data research in the literature. Bibliometric analysis is the application of statistical and mathematical methods to literature such as books and articles as well as other communication media. The British Standards Institution defines bibliometrics as document analysis and looking for patterns using mathematical and statistical concepts (Karim & Soebagyo, 2021). Bibliometric analysis is an analytical approach to analyzing published academic studies and has been widely used in LIS (Library Information Science) studies (Kusumawati, 2023). Bibliometric analysis is used to review publications related to the scope of research to identify research trends, concepts, and keywords needed (Busro et al, 2021).

VOSviewer

According to Eck & Waltman (2023:3), Maps based on network data can be created, explored, and visualized using the software program VOSviewer. VOSviewer can perform the following tasks:

1. Construct a map using network data. Networks can be built initially, or maps can be made based on networks that already exist. VOSviewer can be used to create a network of researchers, research institutions, countries, keywords, and concepts as well as scientific papers and journals. Co-authorship, co-occurrence, citation, bibliographic coupling, and co-citation linkages can be used to connect items in this network. Web of Science, Scopus, Dimensions, Lens, and PubMed files as well as RIS, EndNote, and RefWorks files from reference managers can be entered into

VOSviewer as input to create the network. A different option is for VOSviewer to download data using APIs (such as the Crossref API, OpenAlex API, Europe PMC API, and others).

2. Consider and investigate the map. Network visualization, overlay visualization, and density visualization are the three map visualizations offered by VOSviewer. When working with huge maps with hundreds of elements, the ability to zoom in and out and scroll allow the map to be thoroughly examined.

Researchers can extract valuable information from bibliographical data and visualize it in an easy-to-understand way. It helps in analyzing research trends, collaborations between authors or institutions, and patterns of influence within the scientific literature. VOSviewer can be used as a tool to explore and understand the research landscape in a particular field or to visualize the structure and interrelationships between topics in bibliographic data (Latifah & Sriwidjayanto, 2022). Efficiently collate the literature, establish similarity among selected publications in parameters, and establish significant themes among publications (Nobanee et al., 2021).

Harzing's Publish or Perish

The Publish or Perish (PoP) application was first discovered by a professor in management at Middlesex University named Anne-Wil Harzing which was developed in 2006. This application is provided free of charge for integrated journal reference searches for Crossref, Google Scholar, Google Scholar Profile, and PubMed. The Publish or Perish (PoP) application is also provided free of charge by registering for scientific journal reference searches that are integrated with Open-Alex, Scopus, Semantic Scholar, and Web of Science. The working principle of the Publish or Perish (PoP) application is to develop metadata, stored in RIS format which can be added to a reference manager such as Mandeley (Hutapea, 2023).

This Publish or Perish (PoP) application was created to help academic writers or researchers to find and obtain scientific research journal references for writing scientific papers. The Publish or Perish (PoP) application can also be used to conduct literature reviews and decide which scientific journals to use as referrals and references. Authors can also take advantage of conducting bibliometric researchThe Publish or Perish (PoP) program can show data like citations per author, all publications relevant to a search, average citations per article, and citations per year for scientific journals that will be utilized as references (Hutapea, 2023).

Authors will find it easier to choose scientific journal references by using the Publish or Perish (PoP) application's many display metrics, such as an analysis of the number of authors per article, h-index and parameters related to g-index, average annual increase in individual h-index, three variations on individual h-indexes, and specific time-weighted citation rates. Harzing (2017) added that the results of writing scientific papers that show a good display of citation metrics in Publish or Perish (PoP) applications, the results of these writings have a very good impact on further research. However, if the appearance of the citation metrics shown by scientific work in the Publish or Perish (PoP) application is weak, then the scientific contribution and impact will be of little benefit to society (Hutapea, 2023).

This program is intended to assist authors in a variety of ways, including helping them perform literature reviews, conduct bibliometric research, choose which journals to submit to, prepare for job interviews, and demonstrate the importance of their study even if they just have a few citations (Noeraida & Noorseto, 2020).

Google Scholar

A search engine for scientific publications such journal articles, conferences, books, and theses is called Google Scholar. Some of its features support researchers in the process of disseminating published research results. In addition, Google Scholar helps researchers evaluate and see who is citing their articles (Rostiani & Tjandra, 2022). Google Scholar is used to obtain previously available research title data as a comparison with the entered research title (Rahmatuloah & Gunawan, 2020).

According to Lukman et al (2019), currently there is a lot of free access to search engines related to citations such as Google Scholar as well as innovative bibliometric indicators that assist in objectively analyzing the scientific productivity of journals, authors or institutions. Through innovative bibliometrics, measurement using a new indicator not only considers the number of citations but also the weighting of citations based on an algorithm to measure the influence of articles or authors in scientific communication and the growth of scientific disciplines.

III. Research Method

This study employs the "Bibliography" research method, a form of literature review that compiles and assesses a number of publications on a specific subject. Data collection was carried out using the Harzing's Publish or Perish 8 application using the Google Scholar website as a data collection database because this website contains various kinds of local, national and international journals making it easier for users to find topics, providing easier access than other websites and allowing users to to search for text topics in various publication formats. The documents (research articles, books, etc.) that will be analyzed are documents published from 2018 to 2022 using keywords in the Keywords column "PDCA" and "quality" and a limit on the number of documents of 1000 documents. This is done with the aim of pursing the search for research on the application of PDCA. Based on the data collection criteria, 995 documents were found and stored in the RIS (Research Information Systems) format.

The data stored in the RIS (Research Information Systems) format was then analyzed using the bibliometric method using the VOSviewer 1.6.19 application. VOSviewer is a software tool for creating maps based on network data and for visualizing network patterns and exploring maps based on all types of network data. Network visualization, overlay visualization, and density visualization are the three subcategories of the visualization of network patterns in VOSviewer, according to Eck & Waltman (2023: 8–12). Density visualization aims to show the density or emphasis on research groups, overlay visualization aims to show historical traces based on the year the research was published, and network visualization aims to show whether or not the network is strong or the relationship between research terms. In order to undertake reliable content analysis based on the researcher's name, year of publication, productivity, and research trends, the mapping acquired by VOSviewer can then be utilized as a reference.

Bibliometric analysis in this study was carried out to analyze and map the development of research publications regarding the application of PDCA to improve quality, analyze the network of PDCA implementation to improve quality based on keywords (co-occurrence) and author collaboration (co-authorship), and further research directions in PDCA study systematically.

Susilowati et al. (2022) conducted bibliometric research using VOSviewer as an analytical tool to analyze ethics research and online learning in the past, present, and future using the Publish or Perish software and the Google Scholar website as a database. retrieval of data. In their study from 2022, Farikhoh and Chariri assess and map the major research strands, research advancements, and future research orientations in systematic corruption investigations from 2011 to 2020 in the Scopus database. The important word is Mudharabah/Mudharabah, according to Budianto's research (2022), which charts the growth of research on Mudharabah contracts in Islamic Financial Institutions from 2001 to 2021 by browsing the Garuda website (Digital Referral Garba).

IV. Result and Discussion

Development of Research Publications on the Application of PDCA to Improve Quality

The results of research documents on the application of PDCA to improve quality using the Publish or Perish application using the Google Scholar website with keywords in the Keywords column "PDCA" and "quality" obtained 995 documents. Developments in the growth of publications on the topic of implementing PDCA to improve quality in the 2018 to 2022 range taken from the Google Scholar database through the Harzing's Publish or Perish 8 application show fluctuating developments. Of the total research publications indexed by Google Scholar, namely 995 documents, only 910 documents have year information, while 85 documents do not have publication year information.

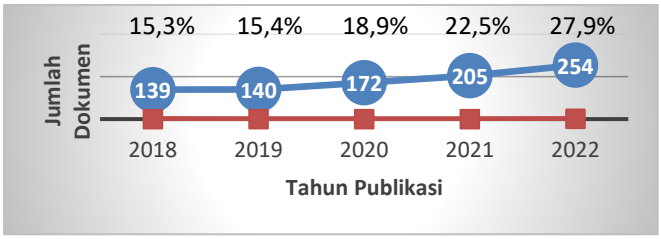

Figure 1. Development of Research Publications on the Application of PDCA to Improve Quality
Source: Publish or Perish (processed)

From Figure 1 it can be seen that the development of publications with the topic of applying PDCA to improve quality occurred the most in 2022, namely reaching 254 publications (27.9%). While the lowest publication occurred in 2018 with a total of 139 publications (15.3%). From 2018 to 2022, it will be divided into three phases, namely before the Covid-19 pandemic (2018-2019), during the Covid-19 pandemic (2020-2021), and after the Covid-19 pandemic (2022). It was concluded in research publications on the topic of implementing PDCA to improve quality from 2018 to 2022 showing an increase every year. The Covid-19 pandemic has not affected research publications on the topic of implementing PDCA to improve quality, so this topic is still in demand and continues to grow.

Peta Jaringan Implementasi PDCA untuk Meningkatkan Kualitas Berdasarkan Kolaborasi Penulis (*Co-authorship*)

After the dataset is stored in RIS (Research Information Systems) format using Publish or Perish metadata, then the dataset is analyzed using the VOSviewer application by selecting the data type "create a map based on bibliographic data". The method used to calculate the dataset is full counting with the aim that the calculations are carried out as is according to researchers who have taken the topic of applying PDCA to improve the quality of their research.

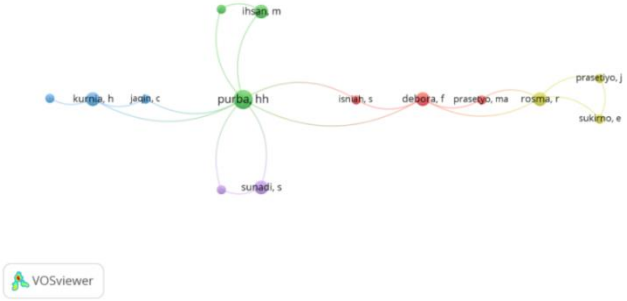

Figure 2. Network Visualization Network in Co-authorship
Source: VOSviewer

Figure 2 shows the network visualization of co-authorship which is characterized by the presence of nodes (circles) representing authors or researchers, and edges (networks) representing relationships between authors or researchers. The collection of nodes equipped with edges explains that there is a correlation or relationship between research on the topic of implementing PDCA to improve quality. Bibliometric analysis based on the author or researcher (author) centered on research conducted by Purba HH or Humiras Hardi Purba. One of the studies conducted by Humiras Hardi Purba with Sarah Isniah and Fransisca Debora (2020) has the highest number of citations (cites) in the Publish or Perish application using the Google Scholar website, namely 98 citations. The network shows the existence of a relationship or collaboration of writers, such as a network (edge) that connects the writer Humiras Hardi Purba with other writers such as Hasanah, Ihsan, Jaqin, Kurnia, Sjafrudin, Hasibuan, Sunadi, Prasetyo, Rosma, Prasetiyo, Sukirno.

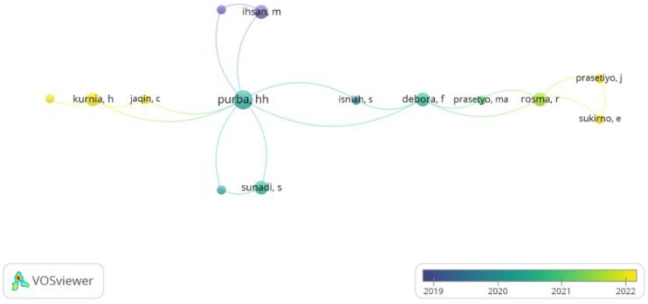

Figure 3. Overlay Visualization on Co-authorship
Source: VOSviewer

Figure 3 shows an overlay visualization on co-authorship that maps the author's historical footprint in research on the topic of implementing PDCA to improve quality. This research is characterized by the existence of nodes that have varied colors and edges that connect one researcher with another researcher. The dark color on the nodes indicates that research has been carried out in the

past for a specified period. For example, the darkest node color (purple) represents 2019 and the lightest (yellow) represents 2022.

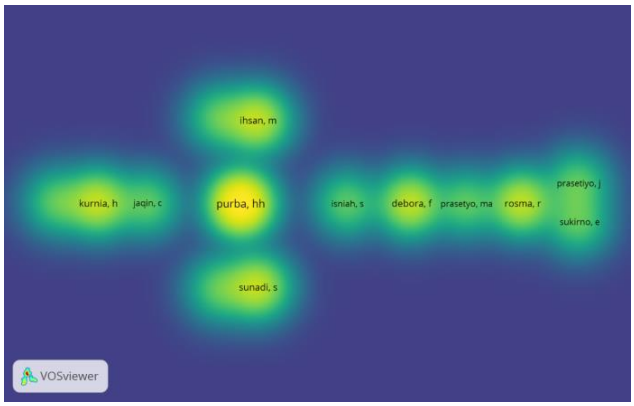

Figure 4. Density Visualization in Co-authorship
Source: VOSviewer

Figure 4 shows the density visualization on co-authorship which identifies the presence of density or emphasis on nodes which means that groups of researchers who research the topic of applying PDCA to improve quality have a relationship with one another. In addition, the level of node saturation in density visualization is indicated by the number of studies involving other studies by citing the author. As shown by Purba HH's research which shows the brightest color node density, in other words, several studies alongside him cite Purba HH's research as a form of research collaboration on the topic of applying PDCA to improve quality.

PDCA Implementation Network Map to Improve Quality Based on Keywords (Co-occurrence)

The dataset is then examined using the VOSviewer tool by selecting the data type "create a map based on text data" after being saved in RIS (Research Information Systems) format using Publish or Perish metadata. This option was chosen to create a network or term relationship based on text data. The fields of the terms are extracted based on the title and abstract while the method used to calculate the dataset is full counting with the aim that the calculations are carried out as is according to research related to the topic of implementing PDCA to improve the quality that has been carried out. There are 61 papers that have an occurrence relationship because a term must appear in at least 10 documents.

According to Hidayat (2020), Clusters are a collection of nodes that are close together (Erc & Waltman, 2014:10). A resolution parameter controls the number of clusters. There are more clusters overall when the parameter value is higher. Clusters in VOSviewer are grouped by color, each keyword in the map is identified by color. Eck & Waltman (2023:43-44), Cluster color files are text files that contain cluster colors. A clustered column, a red column, a green column, and a blue column are the four columns in the cluster color file.

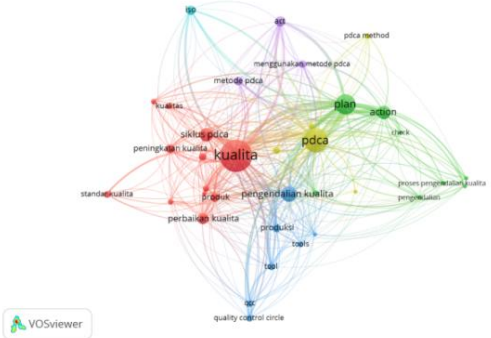

Figure 5. Network Visualization on Co-occurrence
Source: VOSviewer

Figure 5 shows a network visualization of co-occurrence which explains the network or relationship between one term and another in research on the topic of implementing PDCA to improve quality from 2018 to 2022. The 995 documents indexed by Google Scholar can be grouped into 6 clusters. can be identified through the color of each keyword node.

1. Cluster 1 is symbolized in red which includes terms related to the topic of implementing PDCA to improve quality that has been studied, namely effect analysis, FMEA, quality, product quality, quality improvement, product, PDCA cycle, quality standards, TQM, quality improvement proposals.
2. Cluster 2 is symbolized in green which consists of actions, checks, Dr. W Edwards Deming, through the implementation of PDCA, controls, plans, quality control processes, and SPC.
3. Cluster 3 is symbolized in dark blue which consists of the analysis of quality control, quality control, production, QCC, quality control circle, tools, and tools.
4. Cluster 4 is symbolized in yellow which consists of PDCA, PDCA approach, PDCA cycle, PDCA method, and quality.
5. Cluster 5 is symbolized in purple and consists of acts, using the PDCA method, and the PDCA method.
6. Cluster 6 is symbolized in blue which consists of iso.

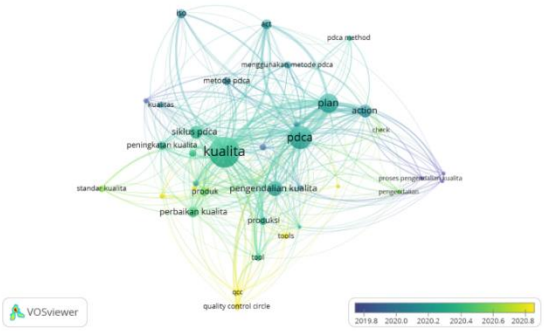

Figure 6. Overlay Visualization on Co-occurrence
Source: VOSviewer

Figure 6 shows an overlay visualization on co-occurrence which explains the mapping or clustering of research trends with the topic of applying PDCA to improve quality based on historical traces or years of research publication. The information obtained from the overlay visualization results in Figure 6 can be used as a reference for identifying and detecting state of the art from research on the topic of implementing PDCA to improve quality which was carried out in the period 2018 to 2022.

In this visualization, the colors on the nodes represent keywords indicating the year of publication. For example, the keyword "quality" has a green node, which means that articles containing these keywords were published from February 2020 to June 2020. Another example is the term "quality control circle" which has a yellow node, which means articles containing the keyword was published in August 2020.

Figure 7. Overlay Visualization on Co-occurrence with the Keyword Dr. W Edwards Deming
Source: VOSviewer

Another example is in Figure 7 the term "dr W Edwards Deming" which has a purple node, which means that articles containing these keywords were published in August 2019.

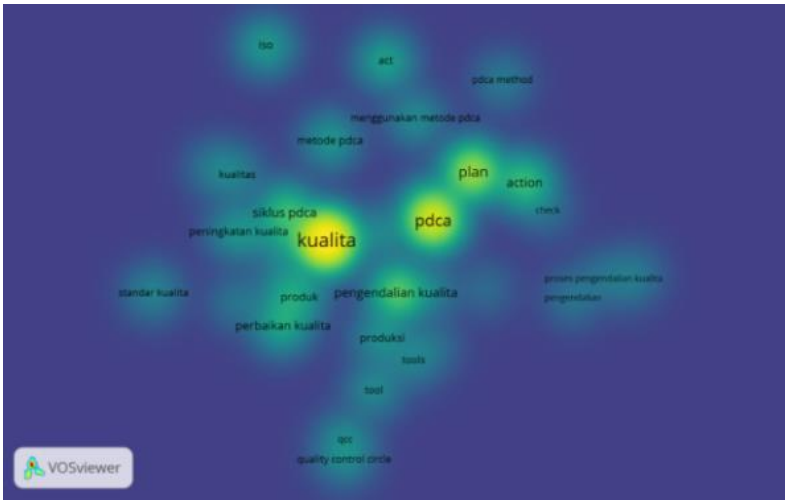

Figure 8. Density Visualization on Co-occurrence
Source: VOSviewer

Figure 8 shows the density visualization on co-occurrence explaining that there are dense areas that have high density at one node with other nodes. The saturation level identified in the number of keywords in research on the topic of applying PDCA to improve quality is marked in yellow, meaning that the area is a term that has been extensively researched and indexed by Google Scholar, for example, the keyword quality, PDCA. Meanwhile, nodes marked with dark colors indicate that these keywords have not been studied much.

Further Research Directions in PDCA Studies

Figure 8 identifies density or emphasis on nodes where the yellow nodes mean that the keyword has been extensively researched and the dark color means the keyword has not been studied much. From these dark keywords, it can generate opportunities to conduct research or research on these topics or keywords, for example, the keyword "ISO" which is connected to the application of PDCA. According to bibliometric analysis of density visualization, which describes strain and low intensity, there is still a dearth of research on the use of PDCA in relation to ISO. Because of this, there is still a lot of room for research on this subject.

PDCA Application to Improve Quality

Quality is one way to survive a company, by paying more attention to quality, the company can develop following the changing times. Companies must control quality because it is an important step to survive. The company is obliged to control from the initial stage to the final stage of the series so that the company can maintain quality. Quality control is also an activity step to provide certainty to the specifications of quality standards.

One of the tools used to improve quality is the PDCA Cycle. The PDCA cycle itself produces several corrective actions, namely corrective, temporary, and permanent. Corrective and permanent actions consist of problems or causes, meanwhile, temporary actions to fix problems. This statement is also supported by research by Amaral et al. (2023), Yoshana et al (2022), and Kurnia et al (2022).

By adding value, PDCA can offer regulated problem-solving for a process. PDCA can be used under many different circumstances, including: (1) the approach to sustainable development, where various improvements are made to the area traversed while resolving issues that arose during the PDCA cycle; (2) a process that is repeated to identify new solutions and improvements, in which case the benefits derived from progress are more invested in the implementation process that is repeated; and (3) the exploration of new solutions.

Ongoing with research conducted by Sun et al. (2023), there are 4 stages in the application of PDCA to improve quality, namely the first stage is the Planning stage where the company must find a problem and then determine the goals of quality improvement; The second stage is the Implementation Stage, with which the company is required to control every work to achieve the process of data collection and data analysis; The third stage is the Inspection Stage where the company has to check and analyze repeatedly to know the problems that arise; The fourth stage is the Disposal stage where the company summarizes the existing problems and the company determines the

method that is suitable for the quality improvement process.

Repair activities with the PDCA method can guarantee the main quality characteristics of the products produced by the quality standards desired by the customer by making continuous improvements. The most dominant factor affecting the company's output is due to defects, with the implementation of the PDCA method it can reduce the level of production defects. The PDCA method can be applied in continuous improvement activities. The application of the PDCA cycle can maximize company profits by reducing the loss potential value. Implementation of the PDCA method can reduce the number of defective products. Productivity is the attainment of goals at the level of output quality and efficient use of resources so productivity is related to aspects of quality, effectiveness, and efficiency.

PDCA method to improve product quality has been widely researched. Research conducted by Utami & Djamal (2018) concluded that after the implementation of improvements made through the application of the PDCA method, the level of defects decreased so the quality of the XX Kaplet strip increased. Prasetyawati et al (2021) stated that the volume of clumping rejects decreased from 2.46% to 0.96% according to company standards so that the quality of the balado Dabur seasoning product increased. Nurdewanti (2022) proved that improving the quality of white compound chocolate products, namely reducing product defects from 12.1% to 2.7%.

The PDCA method can not only improve product quality but can also be used to implement service quality improvements or improve service quality. Research conducted by Rachman (2020) concluded that implementing the PPCA theory in the development of KPI-based quality management (Key Performance Indicators). A KPI formulation was used to carry out the planning. According to Ross et al. (2021), the NAFS mental health application can be utilized specifically for people with mental illness as a kind of mental health first aid and mental health education media by using PDCA, which is an ongoing improvement.

V. Conclusion

Companies must be adaptable in order to deal with any changes and issues that arise in the VUCA era and in the context of global competitiveness. The flexibility of the process is one of the problems that many institutions face, and the PDCA technique is an effective method for detecting these issues. Project management, change management, product development, and resource leveraging are just a few areas in which PDCA can be employed. Implementing a suitable quality control system, having defined targets and phases, and offering creativity in problem-solving and prevention are some of the steps in establishing quality that meets requirements. The findings of using the PDCA method increase a company's efficiency and effectiveness and can be used continuously to control the production process.

The results of this study indicate that in the period 2018-2022, research on the topic of applying PDCA to improve quality has experienced an increase every year. Mapping the development of research publications on this topic based on the author (co-authorship) shows a correlation between researchers. While mapping the development of research publications with this topic based on keywords (co-occurrence) indicates that there is a relationship between concepts in research that is grouped into 6 clusters. Visualization of density which describes the existence of a stretch so that there are opportunities to conduct research or research with these topics or keywords. The findings of using the PDCA method increase a company's efficiency and effectiveness and can be used continuously to control the production process.

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