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Digital Textile Printing and Batik Preservation: A Bibliometric Analysis via VOSviewer

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ABSTRACT

This study examines digital textile printing as an opportunity and, simultaneously, a threat to batik preservation. The study used a bibliometric approach through VOSviewer computational mapping analysis. Article data is obtained from the Google Scholar database using the Publish or Perish reference manager application. The title and abstract of the article are used to guide the search process by referring to the keywords "digital textile printing" and "batik preservation." From the search results of 1000 articles, we found 771 articles that were considered relevant. The study period used as study material is Google Scholar-indexed articles for the last 5 years (2018–2023). The results showed that research related to textile digital printing and batik preservation identified several terms: study, batik, batik preservation development, ink, textile, technology, fabric, digital printing, digital textile printing, and application. From the clusters contained in the network visualization, it can be known: Cluster 1 has 37 items and is marked in red; Cluster 2 has 33 items and is marked in green; Cluster 3 has 27 items and is marked in blue; Cluster 4 has 21 items and is marked in yellow; Cluster 5 has 19 items and is marked in purple; Cluster 6 has 14 items and is marked in light blue; Cluster 7 has 14 items and is marked in orange; Cluster 8 has 12 items and is marked in brown; and Cluster 9 has 2 items and is marked in light purple. Based on the analysis of the development of digital printing, textile publications in the last 5 years show frequent fluctuations. In 2018–2019, it experienced a significant increase from 116 to 200, and then in 2020, the condition decreased to 167. From 2021 to 2022, there was a significant increase of 198 and 238, respectively. We examined how many articles have been published about digital textile printing and its relation to the issue of batik preservation using VOSviewer. This review can serve as a starting point for research related to other materials, especially technological developments related to textiles and batik.

Keywords:
Bibliometric analysis; Digital textile printing; Batik preservation; VOSviewer

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1. Introduction

Digital textile printing comes with the development of Industrial Revolution 4.0, especially today's digital technology [1,2]. Many changes have happened in Industrial Revolution 4.0 [3,6]. The adoption of new technologies has changed the pattern of interaction and communication with each other and the surrounding environment, resulting in new challenges to the management of personal information and online identity [7]. The presence of digital technology today serves as a tool to promote and sustain entrepreneurship so as to encourage economic growth, create job opportunities, and encourage sustainable development [8]. The touch of digital technology through computers can help artists produce visual artwork and be used in the production process of textile printing. Because it has the advantages of cost efficiency, is adaptive to customer demand, and produces detailed and high-quality images [9,10].

The results of a systematic review of Web of Science and Scopus database literature show that of all Industry 4.0 technologies, internet of things (IoT), and RFID applications are the most investigated in the textile and manufacturing industries. Meanwhile, the extensive applications of additive manufacturing/3D printing and augmented reality (AR) are still in their infancy [11]. The study of digital printing in the textile sector is very interesting because, in addition to having advantages, it also has weaknesses. The existence of digital textile printing, in addition to having several advantages over screen printing techniques for traditional textiles, also has the main disadvantage of relatively slow production speed compared to screen printing [12].

Historically, the textile digital printing process first appeared in the early 1990s, and dramatically, its market share has increased in the last five years [13]. Digital textile printing can also contribute positively to preserving classical batik. However, its presence threatens the sustainability of traditional batik. This is why much research regarding batik [14-17].

Digital textile printing efforts are also seen as having an impact on the preservation of traditional batik, such as the preservation of batik motifs, consistency in the creation of batik motifs, the efficiency of the batik production process, and enabling design innovation using digital facilities and features. However, small, and small business actors are engaged in batik and textiles today. In addition to some who consistently maintain batik culture, some use digital textile printing technology to run their business. Digital textile printing is certainly in the process of producing batik motifs that can be done accurately and efficiently, without the need to go through a complicated manual process as in traditional batik making.

In addition, digital textile printing can provide benefits in preserving classical batik, but remember that traditional batik has deep cultural, historical, and artistic values. In particular, the problem in the batik industry in Indonesia is the presence of batik printing in addition to limited labours, shortage of raw materials, development of local fabrics, waste management, coaching and mentoring by Regional Equipment Organizations [18]. The biggest challenge for batik SMEs in Java is the emergence of the batik printing business, while outside Java, it is difficult to obtain raw materials, so there needs to be open innovation supported by the participation of various parties [19]. Thus, using digital printing to make batik cloth motifs violates the concept and definition of batik as a technique for decorating fabrics using obstacle techniques using night candles. Therefore, it is important to maintain and promote the traditional batik-making process and ensure that the knowledge and skills involved in making classical batik are preserved and transmitted to future generations.

Various studies using bibliometric analysis in various fields have been carried out, including bibliometric analysis in the field of design and visual arts education [20,21], textile [22], Craft art [23,24], implementation of the Industrial Revolution 4.0 in the textile and apparel industry [11], art therapy [25], Internationalization of Higher Education [26], and research with research topics on

future trends in education [27], Digital Education and artistic-visual learning in a university environment [28]. Bibliometric studies in the field of printing technology were found, among others: 3D printing in the field of architecture [29], investigating the strategic role of SME digital transformation pathways in the COVID-19 era [30], Application of 3D Printing in the health sector during Covid-19 [31]. However, research on computational mapping of bibliometric analysis in the last 5 years using VOSviewer on data published in digital printing in the textile field about the preservation of batik that has been carried out to determine the development of research has not been carried out. Detailed information for previous bibliometric analysis is in Table 1.

The purpose of this study is to examine digital textile printing as an opportunity and, at the same time, as a threat to batik preservation. The research method uses a bibliometric approach to analyse the phenomenon or challenges through VOSviewer computational mapping analysis. Article data is collected from the Google Scholar database using the Publish or Perish reference manager application to guide the search process by referring to the keywords "digital textile printing" and "batik preservation" as well as editorial titles and abstracts. 771 relevant articles were selected from a database indexed by Google Scholar over the last 5 years (2018–2023). The findings of the study showed that research related to textile digital printing and batik preservation identified several terms, such as: study, batik, development of batik preservation, ink, textile, technology, fabric, digital printing, digital textile printing, and application. Visually, VOSviewer found nine clusters contained in the network visualization. The results also found that research related to the development of textile digital printing and batik preservation in the last five years has fluctuated. This study recommends that the study of digital textile printing and its relation to the issue of batik preservation serve as a starting point to capture an overview of the application of technology and its implementation in batik preservation efforts.

Table 1
Previous studies on bibliometric

No	Title	Ref.
1	Involving Particle Technology in Computational Fluid Dynamics Research: A Bibliometric Analysis	[32]
2	Bibliometric Computational Mapping Analysis of Trend Metaverse in Education using VOSviewer	[33]
3	The Use of Information Technology and Lifestyle: An Evaluation of Digital Technology Intervention for Improving Physical Activity and Eating Behaviour	[34]
4	Strategies in language education to improve science student understanding during practicum in laboratory: Review and computational bibliometric analysis	[35]
5	How language and technology can improve student learning quality in engineering? definition, factors for enhancing students' comprehension, and computational bibliometric analysis	[36]
6	Mapping of nanotechnology research in animal science: Scientometric analysis	[37]
7	Scientific research trends of flooding stress in plant science and agriculture subject areas (1962-2021)	[38]
8	Introducing ASEAN Journal of Science and Engineering: A bibliometric analysis study	[39]
9	A bibliometric analysis of chemical engineering research using VOSviewer and its correlation with Covid-19 pandemic condition	[40]
10	A bibliometric analysis of materials research in Indonesian journal using VOSviewer	[41]
11	Bibliometric analysis of engineering research using VOSviewer indexed by google scholar	[42]
12	Bibliometric computational mapping analysis of publications on mechanical engineering education using VOSviewer	[43]
13	Research trend on the use of mercury in gold mining: Literature review and bibliometric analysis	[44]
14	Domestic waste (eggshells and banana peels particles) as sustainable and renewable resources for improving resin-based brakepad performance: Bibliometric literature review, techno-economic analysis, dual-sized reinforcing experiments, to comparison with commercial product	[45]
15	Bibliometric analysis of educational research in 2017 to 2021 using VOSviewer: Google scholar indexed research	[46]
16	Corncob-derived sulfonated magnetic solid catalyst synthesis as heterogeneous catalyst in the esterification of waste cooking oil and bibliometric analysis	[47]

17	The compleat lextutor application tool for academic and technological lexical learning: Review and bibliometric approach	[48]
18	Use of blockchain technology for the exchange and secure transmission of medical images in the cloud: Systematic review with bibliometric analysis	[49]
19	Computational bibliometric analysis of research on science and Islam with VOSviewer: Scopus database in 2012 to 2022	[50]
20	Digital transformation in special needs education: Computational bibliometrics	[51]
21	Antiangiogenesis activity of Indonesian local black garlic (Allium Sativum 'Solo): Experiments and bibliometric analysis	[52]
22	Characteristics of tamarind seed biochar at different pyrolysis temperatures as waste management strategy: experiments and bibliometric analysis.	[53]
23	The compleat lextutor application tool for academic and technological lexical learning: Review and bibliometric approach	[54]
24	Corncob-derived sulfonated magnetic solid catalyst synthesis as heterogeneous catalyst in the esterification of waste cooking oil and bibliometric analysis	[55]

As a result, this study used VOSviewer software to conduct computational research mapping the bibliometric analysis of Google Scholar-indexed publications. The novelty of this research is in determining the innovation of the focus of digital textile printing studies in connection to batik preservation efforts. The implementation of this research is expected to serve as a reference for researchers to conduct and determine the research theme to be taken, especially those related to the development of modern textiles and traditional textiles. Besides, research on computational mapping of bibliometric analysis in the last 5 years using VOSviewer against published data in the field of digital printing in the textile field to determine the development of research has not been carried out.

2. Methodology

The source of article data used in this study was obtained from journal articles published in the Google Scholar database. We chose Google Scholar in this study because the database was open source. Acquisition of research data was administered using the Publish or Perish manager reference application. This application was used to conduct literature reviews on our chosen topics. Detailed information for using and installing the software and a step-by-step process for obtaining data were described in previous studies [56]. In detail, the process of library search information in searching for data on Google Scholar ware performed through several stages, including:

i. collection of publication data using the publish or perish application
ii. processing of bibliometric data of articles obtained using the Microsoft Excel application
iii. analysis of computational mapping of bibliometric publication data using the VOSviewer application
iv. analysis of the results of computational mapping [57].

The process of searching article data on the Publish or Perish application was used to filter publications using the keywords "digital textile printing" and "batik" based on the requirements of the publication title. The articles used were selected between 2018 and 2023. All data was obtained by June 2023. The data processed in the form of articles that had been collected by the criteria of research analysis was then exported into two types of files: research information system (*.ris) and comma-separated value format (*.csv). Henceforth, to visualize and evaluate trends using bibliometric maps, VOSviewer was used. This application was used to create three variations of mapping publications: network visualization, density visualization, and overlay visualization based on

networks (co-citation) between existing items. When creating a bibliometric map, the frequency with which keywords were set to be found at least 2 times, less relevant terms and keywords were removed.

3. Results and Discussion

3.1 Publication of Research Data

Based on data search through Publish or Perish reference manager application from the Google Scholar database, 771 data articles that met the research criteria were obtained. Data was obtained through article metadata consisting of author name, title, year, journal name, publisher, number of citations, article links, and related URLs. Table 2 presents some examples of published data used in the VOSviewer analysis of this study. Furthermore, the data sample is sorted into the 20 best articles based on the most citations. There were 2010 citations from all articles used in the research. The number of citations per year was 780.63, and the average citation of author's articles was 0.96.

Table 2
Publication data on digital textile and batik printing

No	Authors	Title	Year	Cites	Source
1	Rahman, M.S., *et al.,* [58]	Recent developments of carboxymethyl cellulose	2021	163	Bioresource Technology
2	Malik, S.N. *et al.,* [59]	Hybrid ozonation process for industrial wastewater treatment: Principles and applications: A review	2020	159	3D Printing and Additive Manufacturing
3	Islam, M.M. *et al.,* [60]	Mapping environmentally sustainable practices in textiles, apparel, and fashion industries: a systematic literature review	2021	81	Composite Structures
4	Shah, M.A. *et al.,* [61]	Classifications and applications of inkjet printing technology: A review	2021	53	3D Printing in Medicine
5	Sun, L and Zhao, L. [62]	Technology disruptions: Exploring the changing roles of designers, makers, and users in the fashion industry	2018	50	RSC Advances
6	Choi, S. *et al.,* [63]	The synthesis and characterization of the perylene acid dye inks for digital textile printing	2019	46	Journal of Textile Engineering & Fashion Technology
7	Raja, A.S.M. *et al.,* [64]	Water requirement and sustainability of textile processing industries	2019	39	Dyes and Pigments
8	Alves, L . *et al.,* [65]	Towards circular economy in the textiles and clothing value chain through blockchain technology and IoT: A review	2022	39	Managerial and Decision Economics
9	Mishra, V.R. *et al.,* [66]	UV protective heterocyclic disperse azo dyes: Spectral properties, dyeing, potent antibacterial activity on dyed fabric and comparative computational study	2019	38	Sensors
10	El-Bashir, S.M. *et al.,* [67]	Spectral properties of PMMA films doped by perylene dyestuffs for photo selective greenhouse cladding applications	2019	30	Sensors
11	Bidu, J.M. *et al.,* [68]	Current status of textile wastewater management practices and effluent characteristics in Tanzania	2021	30	Sensors
12	To, C.K.M. *et al.,* [69]	The logic of innovative value proposition: A schema for characterizing and predicting business model evolution	2020	28	Coloration Technology

13	Radoor, S. *et al.,* [70]	An efficient removal of malachite green dye from aqueous environment using ZSM-5 zeolite/polyvinyl alcohol/carboxymethyl cellulose/sodium alginate bio composite	2021	28	Flexible and Printed Electronics
14	An, F. *et al.,* [71]	Rheological properties of carboxymethyl hydroxypropyl cellulose and its application in high quality reactive dye inkjet printing on wool fabrics	2020	26	International Journal of Fashion Design, Technology and Education
15	Qin, H. *et al.,* [72]	Insights into influences of dye hydrophobicity on cleanliness and resolution of fabric ink-jet printing	2020	26	Green Processing and Synthesis
16	CY Wang [73]	Building a network for preserving intangible cultural heritage through education: A study of Indonesian batik	2019	23	3D Printing and Additive Manufacturing
17	Abdelrahman, M. *et al.,* [74]	Review in textile printing technology	2020	23	Materials
18	Yang, H. *et al.,* [75]	Effect of cotton cationization using copolymer nanospheres on ink-jet printing of different fabrics	2018	22	Coatings
19	Cai, J. *et al.,* [76]	Design, synthesis, characterization of water-soluble indophenine dyes and their application for dyeing of wool, silk and nylon fabrics	2020	20	3D Printing in Medicine
20	Kim, YK. *et al.,* [77]	Effects of heat treatment on the characteristics of royal paulownia (Paulownia tomentosa (Thunb.) Steud.) wood grown in Korea	2018	20	Micromachines

3.2 Development of Research in the Field of Digital Textile Printing and Batik

Table 3 shows the development of research in digital textile printing and batik preservation published in Google Scholar-indexed journals. Based on the data shown in Table 3, it is known that the number of studies in digital textile printing and batik is 771 articles from 2018-2023. In 2018, there were 110 articles. In 2019, it increased somewhat to 140 articles. In 2020, there was a slight decrease compared to 2019 to 132 articles. In 2021 and 2022, it increased to 163 and 165 articles respectively. In 2023, there was 88 articles.

Table 3
The development of research on the topic digital textile printing and batik preservation

Year of publication	Number of publications
2018	110
2019	140
2020	132
2021	163
2022	165
2023	61
Total	771
Average	128.5

Based on the number of publications, research on digital textile printing education and batik preservation has been conducted quite a bit every year. The development is also quite volatile, as seen in Figure 1. This data shows that the popularity of research on digital textile printing and batik preservation tends to be unstable.

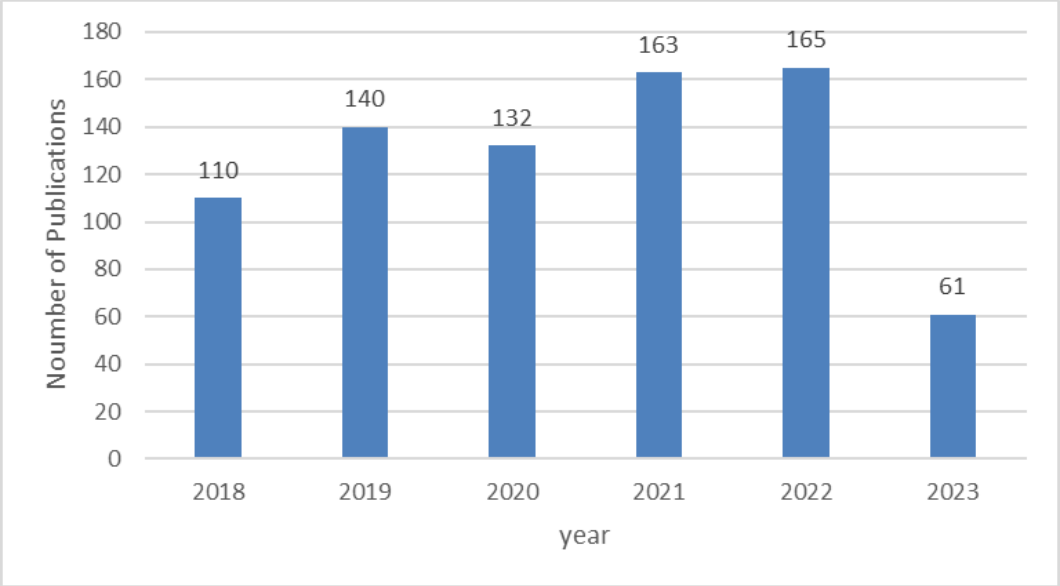

Fig. 1. The level of development of textile digital printing research and batik preservation

3.3 Visualization of the Topic of Digital Printing and Classical Batik Preservation using VOSviewer

Computational mapping was administered on the article data using VOSviewer. From the results of the computational mapping, 179 items were found. Each item found related to digital printing and preservation of classic batik in data mapping was then divided into 9 clusters, namely:

i. Cluster 1 has 37 items and is marked in red. The 37 items are article, batik, batik preservation, benefit, case, case study, challenge, clothing, digital printing technology, digital textile, digital textile printing technology, effort, environment, example, fashion industry, form, future, goal, impact, Indonesia, industry, innovation, journal, market, new approach, pekalongan, preservation, production, role, strategy, study, sustainability, time, value, work, world, year.
ii. Cluster 2 has 33 items and is marked in green. The 33 items are: 3d painting, art, augmented reality, book, chapter, combination, creation, demand, designer, development, digital, digital technology, exploration, fashion, fashion design, hand, image, integration, laser cutting, methodology, motif, overview, pattern, person, practice, project, research, stage, technique, textile design, textile fabric, textile industry, user.
iii. Cluster 3 has 27 items and is marked in blue. The 27 items are: addition, analysis, characterisation, characterization, colorant, cotton, digital textile printing machine, dtg, dte, garmen, google patent, influence, ink, ink jet, inkjet, interest, pigment, preparation, print, printing process, property, reactive dye, silk, synthesis, textile product, use, water.
iv. Cluster 4 has 21 items and is marked in yellow. The 21 items are: abstract, apparatus, aqueous dispersion, capsule, pabric printing, field, invention, medium, nozzle, present invention, print head, printing apparatus, printing methode, quality, resin, surface, system, textile, textile material, textile substrate, unit.
v. Cluster 5 has 19 items and is marked in purple. The 19 items are: application, assessment, company, cotton fabric, digital textile printing process, environmental impact, evaluation, implementation, management, packaging, performance, present study, printing, process, review, technology, textile wastewater, treatment, wastewater.

vi. Cluster 6 has 14 items and is marked in light blue. The 14 items are: consecutive station, device, emboidement, fabric, garment printing, high speed, machine arrangement, nonimpact, plurality, processing station, sequential processing, sheet type, shirt, single operator.
vii. Cluster 7 has 14 items and is marked in orange. The 14 items are: color, composition, digital printing, dtp, effect, fastness, ink jet printer, investigation, object, paper, part, pigment ink, product, self.
viii. Cluster 8 has 12 items and is marked in brown. The 12 items are: acceptance, digital textile printing, droplet, electronic signal, inkjet ink, inkjet printer, inkjet printing. Non-impact printing method, particular piezoelectric inkjet, rapid acceptance, stream, textile printing.
ix. Cluster 9 has 2 items and is marked in light purple. The 2 items are: advantage, order.

The cluster data description above shows a relationship between one term and another. A label for each cluster is assigned to each term with a coloured circle. The circle size for each term varies depending on the frequency with which the term appears [78]. The size of the label circle shows a positive correlation with the occurrence of terms in the title and abstract [79]. The more often this term is found, the larger the size of the label [76]. Visually, the data obtained through the VOSviewer data mapping application analysed in this study consists of three parts, namely: network visualization (see Figure 2), density visualization (see Figure 3), and overlay visualization (see Figure 4) [80].

Figure 2 shows the relationship between terms. Relationships between terms are described in interconnected networks. Figure 2 shows the clusters of each frequently researched term and its relation to the research topic of study: batik, batik preservation development, ink, textile, technology, fabric, digital printing, digital textile printing, and application and development. From the clusters contained in the network visualization, it can be seen:

i. Cluster 1 has 37 items and is marked in red (study, batik, batik preservation)
ii. Cluster 2 has 33 items and is marked in green (development)
iii. Cluster 3 has 27 items and is marked in blue (ink)
iv. Cluster 4 has 21 items and is marked in yellow (textile)
v. Cluster 5 has 19 items and is marked in purple (technology)
vi. Cluster 6 has 14 items and is marked in light blue (fabric)
vii. Cluster 7 has 14 items and is marked in orange (digital printing)
viii. Cluster 8 has 12 items and is marked in brown (digital textile printing)
ix. Cluster 9 has 2 items and is marked in light purple (application).

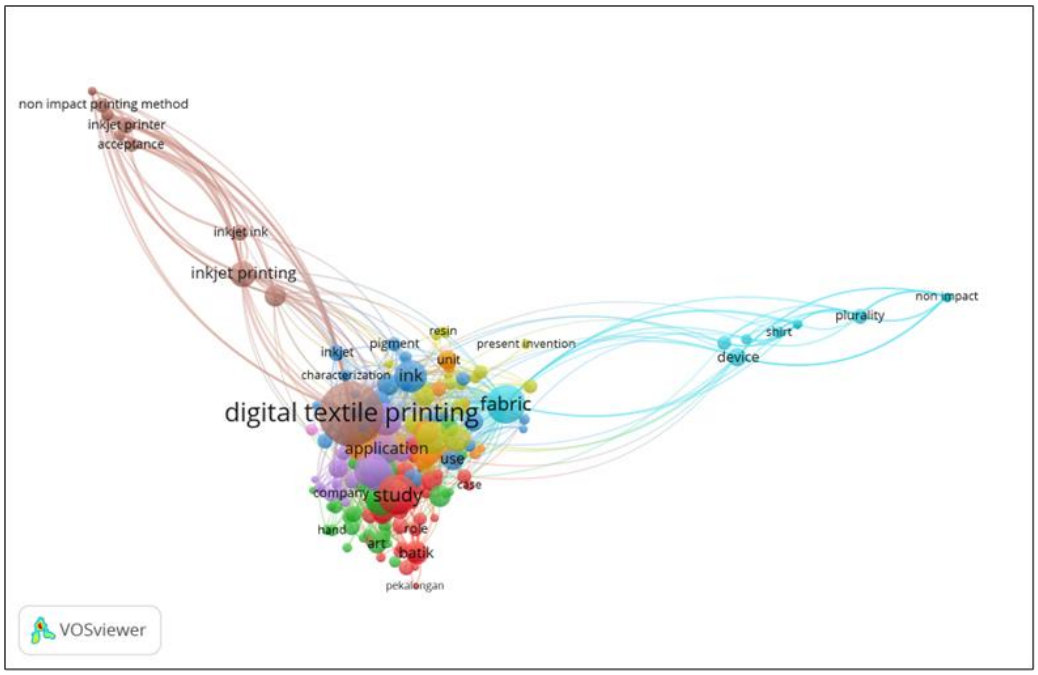

Fig. 2. Visualization of digital keyword networks, textile printing and batik preservation

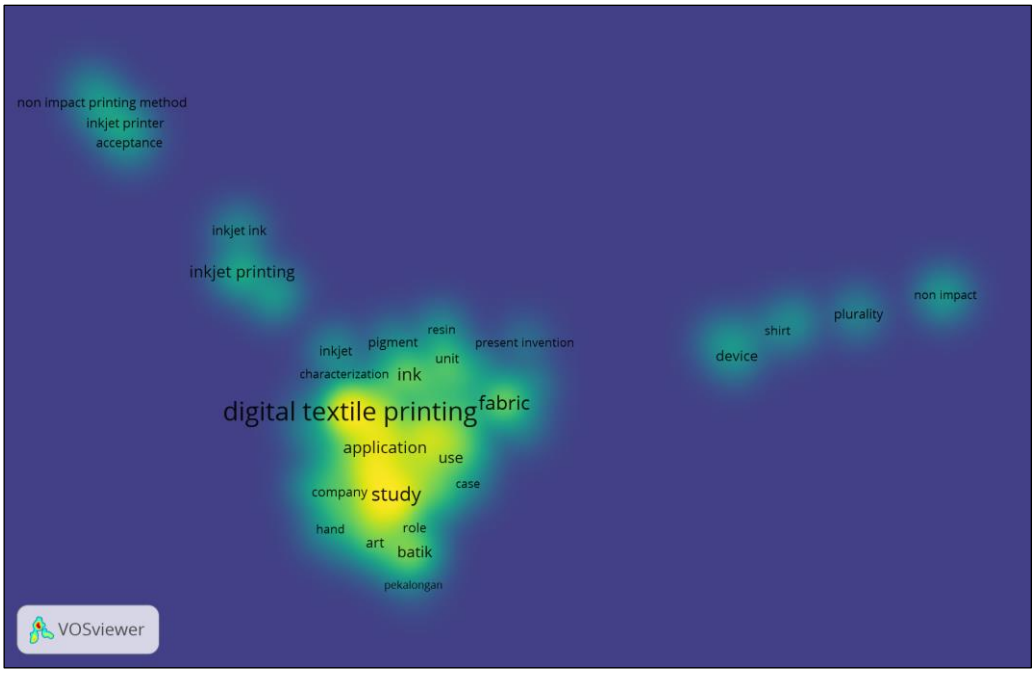

Fig. 3. Visualization of keyword density, digital printing, textile, and batik preservation

Furthermore, the parts of research that are often carried out in detail by article authors are visually presented in the following pictures:

3.3.1 Study

Studies on the topic of batik are conducted not just by university scholars, but also by researchers and lecturers in the disciplines of art and art education. However, it is also commonly done in other areas such as chemistry, physics, technology, textiles, business, economics, and environmental studies. This is undoubtedly linked to various parties' efforts to preserve the heritage of batik as an

intangible culture, which has been recognized by the international community through UNESCO since October 2, 2009.

Figure 5 depicts the visualization of Cluster 1, which contains 106 links, 300 total link strength, and 88 occurrences. The study aspect, according to the image, has a connection with the major theme, which is digital textile printing. Furthermore, the research has connections with textile medium (fabric, paper), textile material (ink, figment), technique (dye), technology (including application, treatment, cotton fabric), industry, product (clothing), industry, batik patterns, art, role, and journals that examine batik.

Study also has relationship with batik preservation, including aspects of Indonesia as a batik-production country, batik patterns, roles, values, forms, processes, application motifs, mediums, systems, benefits, and Pekalongan as one of the places that produce batik as presented in Figure 6. This research topics were still included in cluster 1, which contains 38 links, 81 link strength, and 88 occurrences.

Concretely, efforts to preserve batik as intangible cultural heritage should be carried out jointly between the government, business, and industry, as well as through participation in cultural heritage education. This is reinforced by reports that affirm that batik preservation efforts can be carried out by:

i. connecting cultural heritage education with the context of daily needs and the social environment
ii. cooperation between industry, government, schools, museums, and research institutions
iii. growing attention to cultural heritage through educational processes in schools [81].

Studies related to batik preservation efforts through the development of batik motifs have been established by many batik designers and craftsmen, for example, by raising the source of ideas from the surrounding environment, such as tamarin plants (*Tamarindus indica L*.) as the local cultural identity of Semarang batik [82].

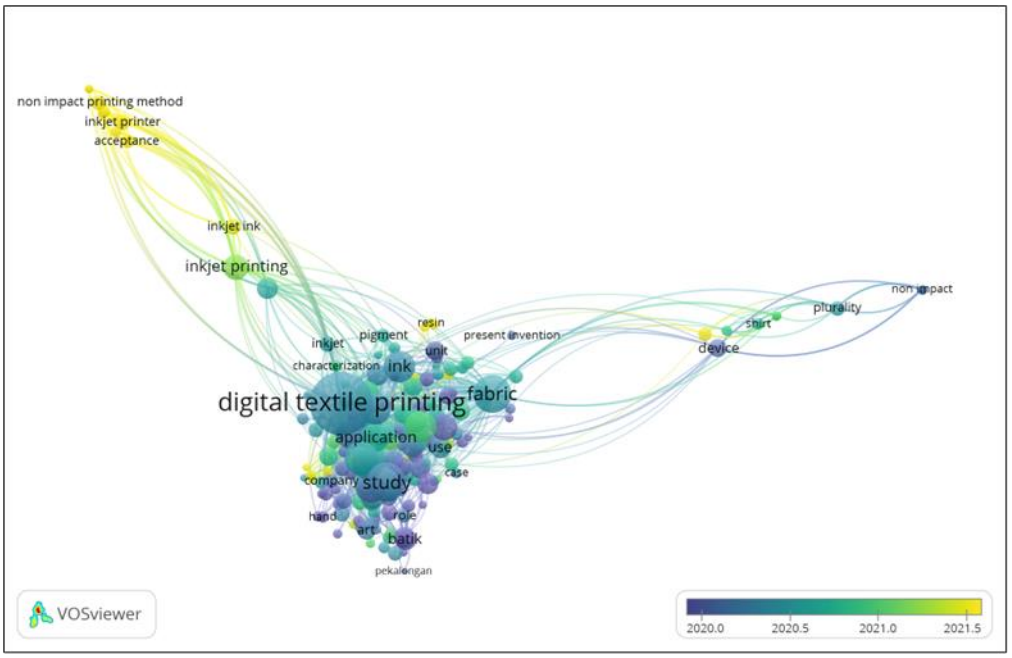

Fig. 4. Visualization of digital keyword overlay, textile printing and batik preservation

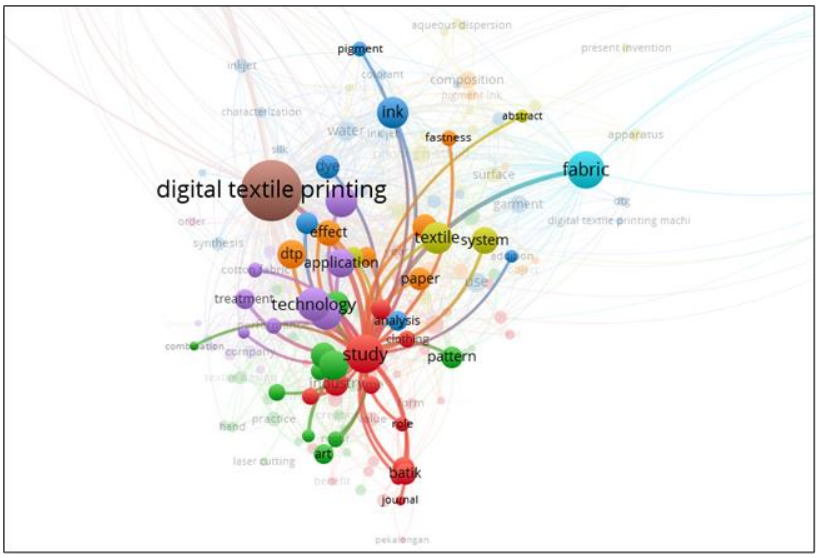

Fig. 5. Research topic "study" and its relationship with other aspects

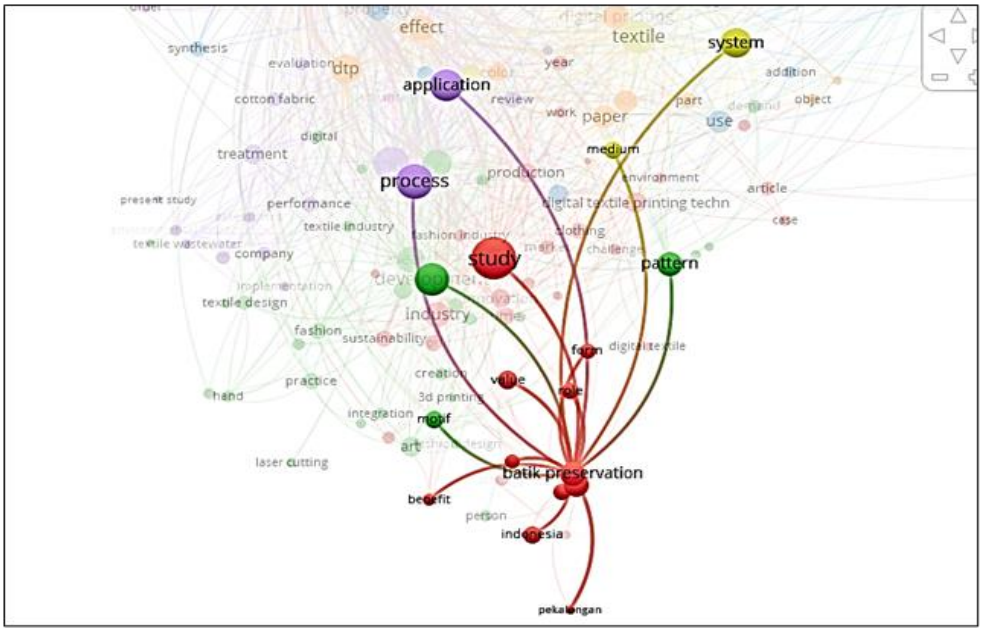

Fig. 6. Research topic "batik preservation" and its relationship with other aspects

3.3.2 Development

Development studies related to digital textile printing and batik preservation are closely related to various other fields of study, such as: printing technology, digital printing, fabric, applications, fashion, art, batik, ink, inkjet printing, textile materials, textile products, companies, and others.

Figure 7 is a detailed visualization of cluster 2 (development), which has 86 links, 207 links strength, and 52 occurrences. The research aspect of "development," according to the image, has a connection with the main theme, which are digital textile printing, technology, medium, production techniques, and materials in the textile industry. In addition, research on development in detail is closely related to products (fashion, art), companies, and people (textile industry players). Development is also related to textile mediums (fabric, textile material), textile material (ink), engineering (textile printing), and production equipment (inkjet printing). The findings are in line with the report showing that technically, digital printing is introduced for mass production in many

clothing factories through two types of textile design, one of which is digital printing that reflects the structure of clothing patterns divided by the types of use, thus forming patterns and textile designs used in the industry [83].

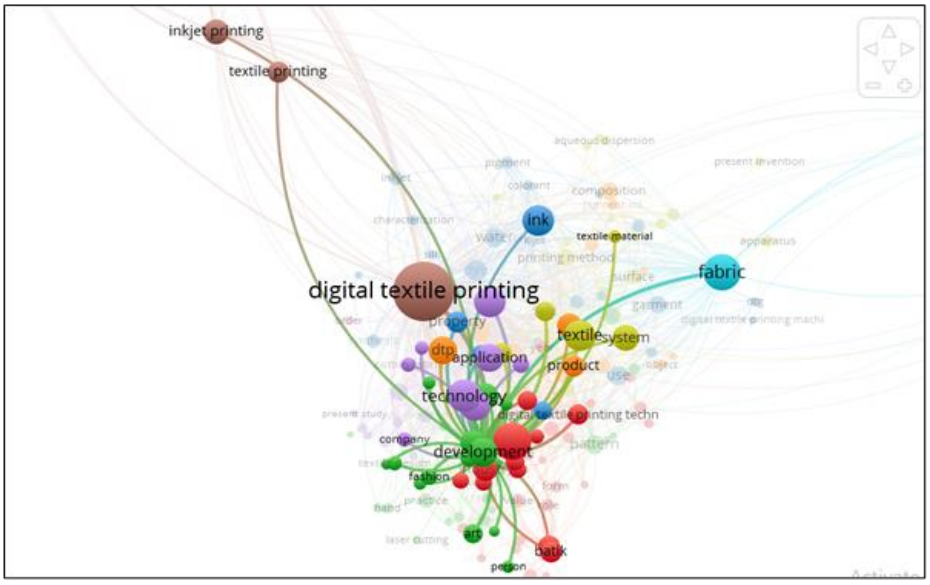

Fig. 7. Research topic "development" and its relationship with other aspects

3.3.3 Ink

The digital textile printing process certainly requires materials to support production processes, such as ink. In Figure 8, the following research related to "ink" is connected to other aspects. In digital textile printing technology, ink plays a major role in producing patterns or designs on fabrics. Digital textile printing is a printing method in which images or designs are transferred directly to the fabric using special inks and digital technology. Within its scope, there are several types of ink used in digital textile printing, including:

i. Pigment ink: Pigment ink provides a more durable colour and is resistant to fading, making it suitable for fabrics that will be washed frequently.
ii. Dye ink: This ink seeps into fabric fibres and gives them a vibrant colour, perfect for thin and light fabrics.
iii. Reactive ink: This ink is used on natural fibres, such as cotton and silk, and produces long-lasting colours that are resistant to washing.
iv. Sublimation ink: This ink is used to print an image on a synthetic fabric and is then activated through heating to apply the image to the surface of the fabric.

Figure 8 is a visualization of cluster 3 (ink), which has 97 links, 282 links strength, and 58 occurrences. The "ink" research aspect of the image is related to the main theme, namely digital textile printing, application, and technology, medium, production techniques, and other textile studies. Research on "ink" in detail is closely related to pigments, colorants, fabrics, dye synthesis, and devices in the form of supporting tools in textile production (inkjet printing).

The most common ink qualities used in digital printing have no solubility in water or no affinity for any fibres, which results in a binder demand to create a strong bond between pigment and fibre. The best ink formulation based on the test results are the KEOJET PGT binder solution, which is 25%, and the catalyst PGT catalyst, which is 12% [13]. The use of toner as a powder mainly consisting of

polymers and dyes is used as ink in digital printing. Changes in production conditions, such as increased time or agitation levels, separately cannot produce high-quality color printing toners. The increase in polarity of the pigment results in better dispersion and lower particle size with a narrower distribution, while changing the characteristics of the pigment does not affect its toner shape or thermal properties [84].

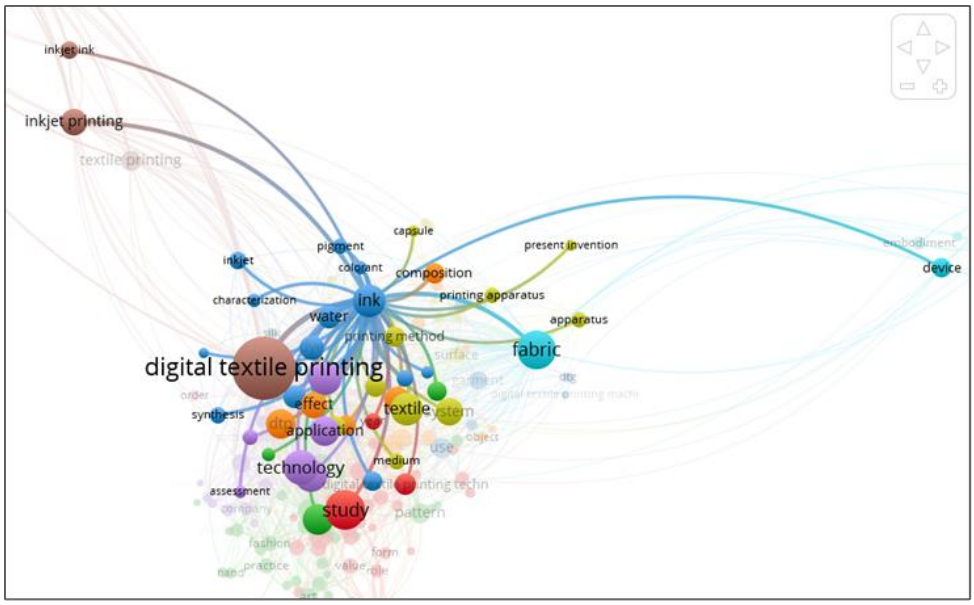

Fig. 8. Research topic "ink" research topic and its relationship with other aspects

3.3.4 Textile

Textile is a term used to refer to different types of materials made from natural or synthetic fibres and used in the manufacture of textile products, such as clothing, furniture, fabrics, and more. Based on the term, the feeding textile concept covers various aspects, including fibre production, spinning, weaving, dyeing, printing, and finishing to create a variegated final product.

Figure 9 shows the visualization of cluster 4 (textile), which has link: 106, total link strength: 259, and occurrence: 60. The research aspect of "textile," according to the image, has a relationship with other aspects, such as digital textile printing, technology, application, medium (fabric), material (ink, water), garment, production equipment (inkjet printing, and supporting devices), involvement of apparatus, effect, and art.

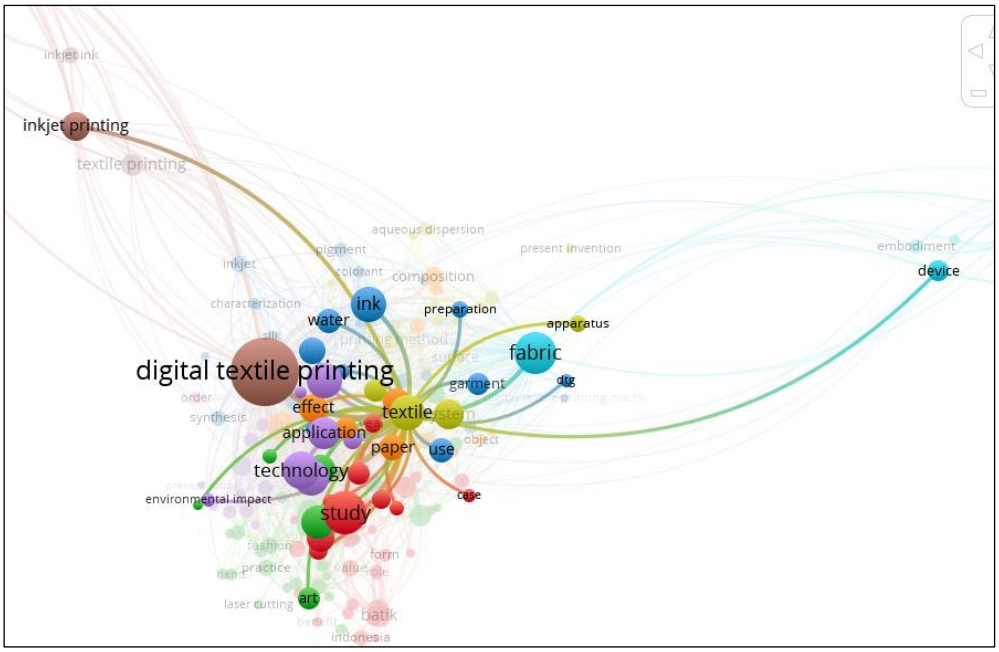

Fig. 9. Research topic "textile" research topic and its relationship with other aspects

3.3.5 Technology

Digital textile printing certainly requires technology when running the textile production process. The technology in question includes digital technology, fabric technology, material technology, and production technology, as well as development technology in the digital world of textile printing.

Technological development in the textile production process plays an important role. Figure 10 shows the visualization of cluster 5 (technology), which has 107 links, 326 total link strength, and 67 occurrences. This aspect of "technology" research based on the image above has a relationship with other aspects, especially digital textile printing, applications, inkjet printing, and wastewater. In other aspects, the existence of technology is also related to studies, medium (fabric, paper), materials (ink, water), garments, and production tools (inkjet printing). Technology is also related to textile patterns, fashion, 3d printing, art, and hand.

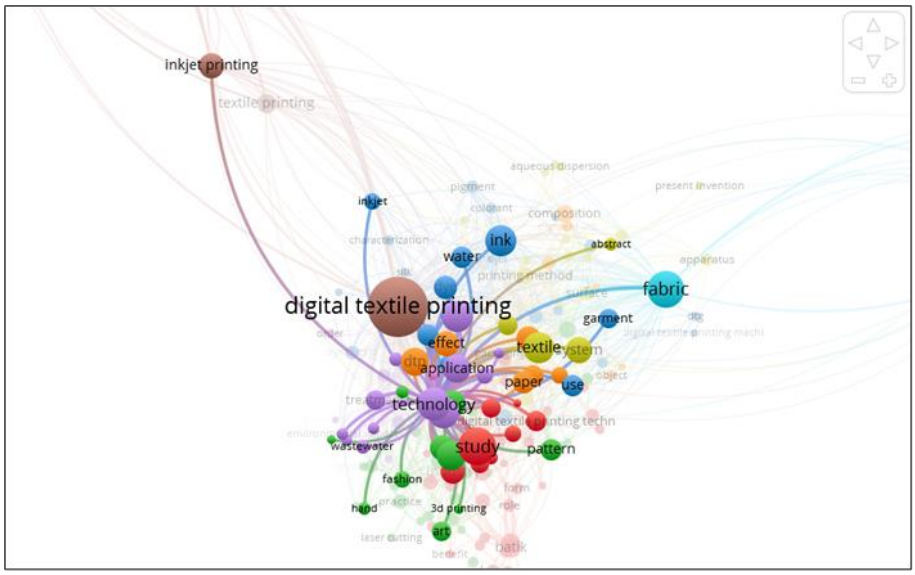

Fig. 10. Research topic "technology" and its relationship with other aspects

The increase in the number of small and medium enterprises (SMEs) in the batik sector in Indonesia has an impact on increasing wastewater. For this reason, there needs to be technological innovation in batik wastewater treatment equipment [85]. Various efforts to reduce the impact of waste can be done through the construction of wastewater treatment plants with conventional bioprocesses, which can be increased to achieve strong dye treatment by installing an ozonation process as a pre-treatment to treat azo dyes in batik wastewater [86]. In addition, efforts to minimize environmental pollution are also in the form of the use of natural colours by utilizing natural pigments from various plant organs (leaves, wood, stems, bark, and fruits) from various species, such as *Caesalpinia sappan*, *Ceriops candolleana*, *Maclura cochinchinensis*, *Indigofera tinctorial*, *I. arrecta*, *Rhizopora spp.*, *Strobilantes cusia*, and *Terminalia bellirica* [87]. Efforts to utilize natural colours to increase batik production have also been carried out through the use of clove leaves (*Syzygium aromaticum L.*) [88] and mango seed extract (*Mangifera indica L.*) as a natural dye for environmentally friendly batik fabrics [89].

Inkjet digital textile printing (IJDTP) is a new technology that offers product development opportunities that can be used by craftsmen, designers, artists/craftsmen, and small business owners/entrepreneurs in computer-aided design, colour control, and print design. However, 624 respondents indicated that they judged IJDTP to have below-average abilities and competencies. This research indicates the need for good mastery of skills to apply technology for educators and practitioners [90]**.** In the field of batik business, the presence of the industrial revolution 4.0 marked by the advancement of digital technology requires companies to continue to innovate products (more modern designs; creating new innovation; design contemporary, unique, thematic, and following fashion trends) and implement digital product marketing as a strategy for the industry to maintain and develop products in local and global markets [91].

3.3.6 Fabric

Fabric as a medium and material for producing textiles has certain characteristics. Figure 11 shows the visualization of cluster 6 (fabric), which has 104 links, 352 total link strength, and 83 occurrences. Like other research, the study of "fabric" has many relationships with other aspects, such as digital textile printing, the use of technology and applications, materials (ink, pigment, and colorant), production technology (textile printing), and production equipment (inkjet printing). Fabric is also closely related to the embodiment of products, shirts, devices, and plurality.

The above findings are reinforced by the report, which confirms that the diversity of batik fabrics needs to be addressed as an effort to inherit digital technology, innovation of batik fabric patterns, and methods to extract batik fabric patterns and elements. The development of a digital image of batik fabric obtained through adjustments to the texture and type of fabric material can reflect the characteristics of the integrity of patterns and elements [92]. In particular, pre-treatment and thread type can change fabric surface characteristics and thus impact inkjet digital printing quality, including colour fastness, colour shade, iridescence, and colour strength and fastness [93].

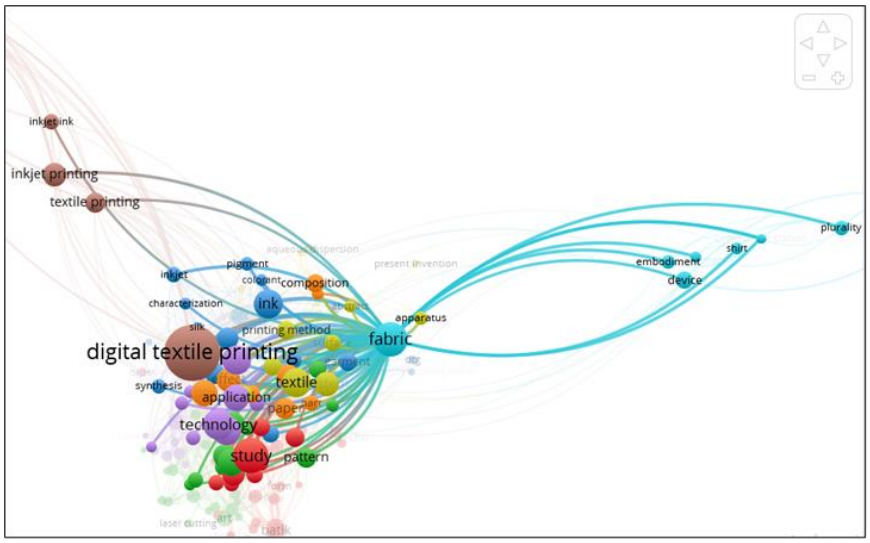

Fig. 11. The research topic "fabric" and its relationship with other aspects

3.3.7 Digital textile printing

This "digital textile printing" research is the main topic of this paper. Based on the results of visually presented data, this topic is very much researched. This is corroborated by the data in Figures 2, 3 and 4. In addition to these topics, the topics of "study" and "technology" are topics that are also widely researched by researchers according to their respective fields of study (See Figure 3).

Figure 12 shows the visualization of cluster 8 (digital textile printing), which has 147 links, 1014 total link strength, and 232 occurrences. Figure 12 above explains the existence of "digital textile printing," which, like other research topics, certainly has a relationship with other aspects, especially with engineering fields (textile printing, inkjet printing, ink injection, inkjet printer, acceptance, particular piezoelectric inkjet, non-impact printing method). The relationship with other aspects is also very close, such as technology, application, material (ink, pigment, synthesis), textile, pattern, role, and journal. Digital textile printing is also related to efforts to realize and use it in shirts.

Along with current technological advances, in addition to the use of relatively cheap and easy synthetic dyes, natural dyes such as tilapia dye have also been extensively developed to improve the industrialization process of batik and textiles with printing technique [94]. In the short term, digital textile printing is one of the most important manufacturing processes for mass customization of clothing items. To produce quality products, strength and colour fastness are very important to note [95]. From an environmental perspective, the existence of digital textile printing (DTP) is considered an environmentally friendly process because its wastewater production is relatively small compared to conventional textile printing systems [96].

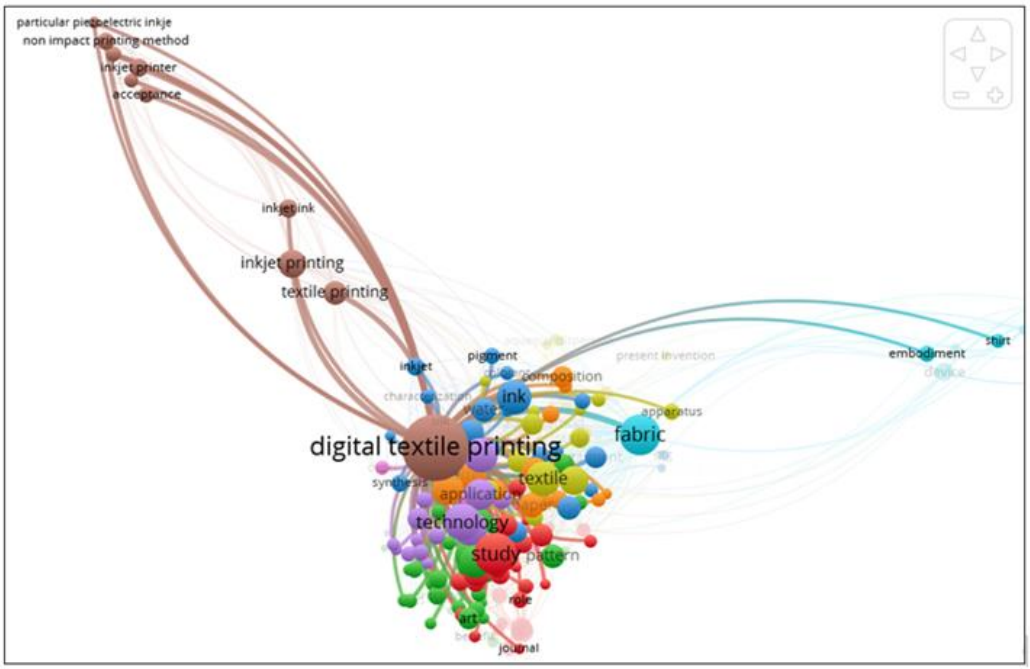

Fig. 12. Research topic "digital textile printing" and its relationship with other aspects

4. Conclusions

This study aims to conduct a computational mapping analysis of the bibliometric data of research articles. The publication themes taken in this study are "digital textile printing" and "batik preservation." Papers are taken from the Google Scholar database via Publish or Perish. This manuscript's publication specifies the titles and abstracts of the literature data used in this study. Based on search results, 771 relevant articles were published between 2018 and 2023. The results reveal fluctuation on research on digital textile printing and batik preservation. The results reveal fluctuations in research on digital textile printing and batik preservation. The results showed that research opportunities on digital textile printing still have a fairly high chance and can be associated with several studies, such as textiles (batik), batik preservation, textile development, dyes (ink), textiles, technology, textile materials (fabric), and comprehensively the field of digital textile printing. In particular, the authors recommend that future researchers focus more on studying batik preservation efforts. It's possible that small and medium-sized industries currently engage in the process and produce of batik culture as both an opportunity and a threat due to the presence of digital textile printing.

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