Digital Transformation in Upcycling-based Craft Industry: A Systematic Literature Review

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ABSTRACT

The current development of digital technology provides easier access for various industries, including the craft industry, which is beginning to adopt digital transformation in its business processes. However, the upcycling-based craft industry still needs to be explored. This industry involves repurposing unused materials or items to create products of higher value than their original state. This concept aligns with government initiatives related to green industries and the implementation of the circular economy. The upcycling-based craft industry faces challenges such as limited raw materials, product form exploration, skilled human resources, innovation, and product design development. This research analyses the literature on the upcycling-based craft industry, focusing on five main variables: Digital Transformation (DT), Circular Economy (CE), Product Design and Innovation (PDI), Sustainable Value Creation (SVC), and Upcycling (U). The methodology employs a Systematic Literature Review (SLR), sourcing articles indexed in Scopus from the ProQuest and ScienceDirect databases through identification, screening, eligibility, and inclusion phases.

Consequently, 105 articles were selected and analysed using meta-analyses in NVivo 12 Pro based on discussion focus and variable relationships within the context of the upcycling-based craft industry. The findings of this research reveal that research needs in the context of digital transformation (DT) are crucial in advancing upcycling practices. Digital technology integration into the design, production, and distribution processes can significantly contribute to promoting sustainable value creation and product design innovation. The conclusions of this study identify potential areas for further research and fill the knowledge gap related to the potential of digital transformation (DT) within the upcycling-based craft industry.

Keywords: digitalisation, crafts, upcycling, transformation, sustainable, information

ABSTRAK

Perkembangan teknologi digital saat ini memberikan kemudahan akses bagi berbagai industri, termasuk industri kerajinan, yang mulai mengadopsi transformasi digital dalam proses bisnisnya. Namun, industri kerajinan berbasis upcycling masih relatif belum banyak dieksplorasi. Industri ini melibatkan penggunaan kembali bahan atau barang yang tidak terpakai untuk menciptakan produk dengan nilai lebih tinggi daripada keadaan aslinya. Konsep ini sejalan dengan inisiatif pemerintah terkait industri hijau dan penerapan ekonomi sirkular. Industri kerajinan berbasis upcycling menghadapi tantangan seperti keterbatasan bahan baku, eksplorasi bentuk produk, sumber daya manusia yang terampil, inovasi, dan pengembangan desain produk. Penelitian ini menganalisis

literatur tentang industri kerajinan berbasis upcycling dengan fokus pada lima variabel utama: Transformasi Digital (DT), Ekonomi Sirkular (CE), Desain Produk dan Inovasi (PDI), Penciptaan Nilai Berkelanjutan (SVC), dan Upcycling (U). Metodologi yang digunakan adalah Systematic Literature Review (SLR), dengan mengambil artikel yang diindeks di Scopus dari database ProQuest dan ScienceDirect melalui tahapan identifikasi, penyaringan, kelayakan, dan inklusi. Sebanyak 105 artikel dipilih dan dianalisis menggunakan meta-analisis di NVivo 12 Pro berdasarkan fokus diskusi dan hubungan variabel dalam konteks industri kerajinan berbasis upcycling. Temuan penelitian ini mengungkapkan bahwa kebutuhan penelitian dalam konteks transformasi digital (DT) sangat penting dalam memajukan praktik upcycling. Integrasi teknologi digital ke dalam proses desain, produksi, dan distribusi dapat memberikan kontribusi signifikan dalam mendorong penciptaan nilai berkelanjutan dan inovasi desain produk. Kesimpulan dari penelitian ini mengidentifikasi area potensial untuk penelitian lebih lanjut dan mengisi kesenjangan pengetahuan terkait potensi transformasi digital (DT) dalam industri kerajinan berbasis upcycling.

Kata Kunci: digitalisasi, kerajinan, upcycling, transformasi, keberlanjutan, informasi

INTRODUCTION

The development of digital technology plays a crucial role across various industrial sectors, including the handicraft industry. Research on the application of digital technology in this field has been extensively discussed, particularly regarding digital marketing and e-commerce [1]. These advancements facilitate the integration of online and offline strategies to enhance market reach and operational efficiency. However, systematic studies concerning the implementation of digital transformation in the upcycling-based handicraft industry still need to be completed.

Upcycling transforms waste or unused items into new products with more excellent value than their original forms [2]. This concept aligns closely with circular economy initiatives aiming to reduce waste and optimise resource utilisation [3]. In Indonesia, circular economy strategies have been adopted in the National Industrial Development Master Plan 2015-2035 by Law No. 3 of 2014, which mandates the implementation of green industry through circular economy practices [4]. A vital element of the circular economy is the application of the 6R principles: reduce, reuse, recycle, recover, redesign, and remanufacture [5], which represents an essential approach to creating sustainable value.

Despite the significant potential of upcycling to support green industry initiatives, upcycling-based handicraft industries still face challenges, such as limitations in raw materials [6], [7], [8], [9], [10], the exploration of simple forms from raw materials [6], [10], [11], [12], and a lack of human resources (HR) with specialised skills for product innovation and design development [6], [7], [11], [12], [13].

Digital transformation is a potential solution to address these challenges. It involves fundamental changes in business processes, organisations, and operational models through the adoption of digital technologies aimed at creating new value [14], [15], [16], [17]. These technologies have been shown to assist in various aspects, such as overcoming raw material limitations [18], driving product design innovation [19], and enhancing human resource skills [20].

Based on an initial literature review, this study's research question is: To what extent is the application of digital transformation related to Sustainable Value Creation, Product Design and Innovation, and Circular Economy within the upcycling-based handicraft industry? This study employs a Systematic

Literature Review (SLR) methodology, examining articles from indexed databases such as ProQuest and ScienceDirect. Following the identification, screening, eligibility, and inclusion stages, 105 articles were analysed using NVivo 12 Pro software to explore the interconnections between digital transformation, circular economy, product design innovation, and upcycling. The results of this analysis are expected to fill the knowledge gap regarding digital transformation in the upcycling-based handicraft industry and support broader circular economy implementation.

In conclusion, this research provides an initial overview of the potential of digital transformation to advance upcycling practices in the handicraft industry while identifying opportunities for further research related to digital technology's contributions to the green industry and circular economy initiatives.

BACKGROUND

Circular Economy

Circular Economy (CE) is a regenerative process involving slowing, closing, and narrowing material and energy resource loops and managing waste, emissions, and energy leaks [3]. Its goal is to maintain products and materials at their optimal value and function, reduce waste and pollution, and support a regenerative economic system [11]. According to [21], CE involves the reuse of products, remanufacturing, repair, and more efficient and economical recycling than conventional recycling. Furthermore, the United Nations Environment Assembly defines CE as an economic paradigm that encourages the reuse, remanufacturing, recycling, or recovery of all products and materials to maintain their value and function, emphasising resource preservation during the economic period [22]. In the context of integrating CE principles into material flows, end-of-life management based on services that consider energy a key element must be efficiently managed to achieve high value through proper asset management [23].

From the definitions of CE presented above, the Circular Economy (CE) is a regenerative economic approach that focuses on slowing, closing, and narrowing material and energy loops within resources, including reusing product reuse, remanufacturing, repair, and recycling. The primary goal is to optimise function and value to preserve products and materials, focusing on energy efficiency.

Upcycling

The definition of upcycling has been commonly used in previous research, but there are two dominant, differing perspectives. First, upcycling refers to the reuse of discarded materials to enhance the value of those materials [6]. Second, upcycling is defined as transforming waste materials into value-added products through unique and creative craft methods [24]. Another definition of upcycling is the retrieval and integration of components and materials previously discarded into various products within an open-loop cycle [25]. In [2] perspective on the definition of upcycling, there are two main approaches. First, the focus is on material recovery to " safely maintain the value and quality of the material through improved recycling or remanufacturing." Second, upcycling can also be interpreted as creating products with higher value and quality through transforming, reusing, or recreating waste or discarded materials/products, whether by companies or individuals. Upcycling can also be considered an art or craft that creates beautiful objects.

In summary, the consensus on the definition of upcycling is a creative approach to transforming, reusing, or recreating waste materials or discarded materials/products through a transformation process that integrates components and materials in an open-loop cycle into new products/crafts with added value.

Sustainable Value Creation

Literature on sustainable value creation begins with the term "sustainability." There are two main concepts of Sustainability: strong Sustainability, which suggests that natural resources are irreplaceable, and weak Sustainability, which argues that human technological innovation can replace them ([26], as cited in [27]. Sustainability can also mean maintaining activities over the long term without harming the environment [28]. In the context of sustainable development, the perspective on value creation needs to be integrated [28]. Integrating value creation in the context of Sustainability can be achieved through innovative business models that use digital technology such as smart applications, drones, 3D printing, and collaborative crowdsourcing services to provide added value to customers [12]. The paradigm of sustainable value creation (SVC) in the manufacturing sector requires the development of technology and innovation at all stages of products, processes, and systems. This includes product and process design that considers the long product life and the reuse of materials in products [5].

Based on the explanations of the definitions and paradigms above, the conclusion for the definition of sustainable value creation (SVC) is a concept that involves the process of creating added value through technological innovation and business models with an approach to product, process, and system design that considers product lifespan and the repeated use of materials in products as an effort to sustain value with the application of digital technology.

Innovation and Product Design

Innovation refers to developing new technology or combining technologies that meet market demands [29]. Research by [30] describes innovation as new product creation, equipment, or services introduced to the market. Innovation encompasses conceiving and implementing new ideas, products, or processes that provide value to individuals and organisations [31]. This process involves the development of new technologies, methods, and business models to meet needs [32]. Innovation can be divided into two main aspects: product innovation, which refers to the introduction of new technologies or combinations of technologies in the form of commercial products, and process innovation, which involves changes in production processes to improve output or efficiency [32]; [29] On the other hand, the definition of product design is the process of creating solutions that meet user needs and desires. This process involves the integration of technical, business, and aesthetic factors and considers production, Sustainability, and other aspects. Product design includes stages such as problem identification, concept exploration, solution development, and the efficient and effective implementation of products [33].

Therefore, this research develops the definition of product design innovation as the process of creating new products or improving existing products through a design approach that involves problem identification, concept exploration, solution development, and product implementation aimed at meeting user needs and desires and providing added value by integrating technical, business, aesthetic aspects and considering Sustainability.

Digital Transformation

[14] define digital transformation (DT) as the utilisation of new digital technologies such as social media, mobile devices, analytics, and others to enhance core aspects of business, such as improving user experiences, optimising operations, or creating new business models. DT can also be described as a significant process involving substantial changes within an entity, including its characteristics, through integrating information technology, computing systems, communication mechanisms, and interconnections [17]. From another perspective, [16] defines digital transformation as an organisational transformation process triggered by actions resulting from digital disruption adoption driven by technological advancements. Digital transformation refers to fundamental changes in form, function, or structure that use digital technology to create new value. More than just technology, DT involves a series of updates and strategic changes to create value at various levels within various entities. "Entities" here refer to organisations and encompass challenges and needs within ecosystems and societies [15].

Based on the above definitions, the definition of digital transformation (DT) is the process of adopting digital disruption driven by technological advancements, creating fundamental changes in form, function, or structure within core business areas such as enhancing user experiences, optimising operations, or creating new business models, through modifications to the characteristics of entities, including organisations and ecosystems, using information technology, computing systems, communication mechanisms, and interconnections to generate new value.

RESEARCH METHOD

This study employs the systematic literature review (SLR) method conducted concurrently with theoretical analysis to address the research questions related to the discussion of upcycling-based craft industries within the context of the variables Digital Transformation (DT), Circular Economy (CE), Product Design and Innovation (PDI), Sustainable Value Creation (SVC), and Upcycling (U).

Identification

The systematic literature review approach in this research aims to identify the extent of research conducted within the scope of upcycling-based craft industries, focusing on aspects such as a) the upcycling business's development, b) analysing the sustainable value creation process, c) exploring innovation and product design processes; d) identifying factors in digital transformation related to innovation and product design. With a focus on the above aspects, this systematic literature review provides a more comprehensive insight into upcycling-based craft industries, the sustainable value creation process, and the impact of digital transformation on innovation and product design.

Data Collection

The search for relevant literature within the scope of upcycling-based craft industries uses more specific keywords. Collecting journal data is carried out through two databases, ScienceDirect and ProQuest, which contain international journals indexed in Scopus. In the literature search phase on both of these platforms, the following search syntax is used: STRING ("code" OR "code") AND ("code" OR "code"). This syntax is utilised to retrieve data with specific code combinations and variations. Details regarding the STRING data can be found in Table 1 below.

***Table 1**. String data for Literature Search*

STRING				
Combine 1				Combine 2
behaviour, activity, exploration, circular, management			OR	production, design, process, material
crafter, artisan, practical, designer	OR	collaboration, organisation, community, society		
upcycle, upcycling			OR	Industry, craft, business, enterprise
sustainable, circularity			OR	value, creation, development
product, design, material, process	OR	innovation, modification, management		
economy, rethink, refuse, reduce, repair, reuse, refurbish, remanufacture, repurpose, recycle, recover			OR	circular, waste, material Management, processing
digital, digitalisation	OR	transformation, innovation, ecosystem, technology		

Selection of Studies

From various search combinations conducted, a total of 549 journal articles were found through two databases, ScienceDirect and ProQuest, which contain journals indexed in Scopus. Additionally, from an analysis of the reference lists recorded in the selected literature reviews, one additional article [34] was added, considering the consistency of the authors in that article and its relevance to the subsequent articles [2], [8], [35], [36], [37], [38], [39], [40], [41] and its relevance to the research scope in the field of upcycling.

Data Extraction and Monitoring Progress

The initial process involved the identification of a total of 550 articles, and through data merging, 270 duplicate articles were found. Furthermore, 80 articles did not meet the established criteria, for instance, because they needed to align with the research scope, as indicated by the article titles. The next stage was the screening process of the 200 articles, and through this stage, 55 articles were found not to align with the research scope, based on the assessment of the article titles and abstracts (see Figure 1).

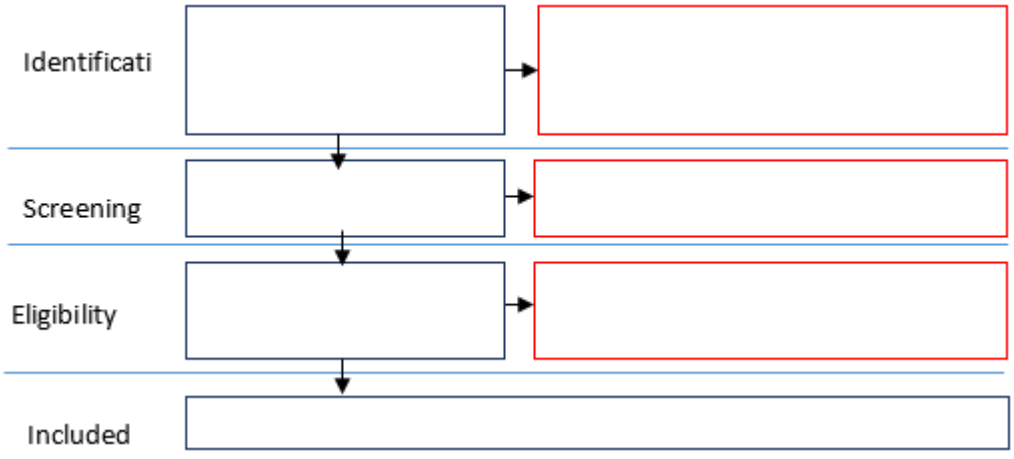

Figure 1. Systematic Literature Review (SLR) Process Diagram from Identification, Screening, Eligibility, to Included

The eligibility stage involved a more in-depth review of 145 full articles, involving a peer-review process to ensure that the included journals met the highest standards of scientific study quality. Furthermore, 40 other articles were excluded for specific reasons, such as not directly relevant to the research topic. Thus, 105 articles were selected for examination in this systematic literature review.

RESULT AND DISCUSSION

The research trends within the publications of 105 articles over the past twelve years demonstrate a significant increase in discussions related to upcycling, circular economy, Sustainability, design and product innovation, craftsmanship, and digital transformation. As shown in Figure 2, 2022 has the highest number of relevant articles, totalling 22. This indicates a high level of significance for the scope of this research in the context of the forthcoming years.

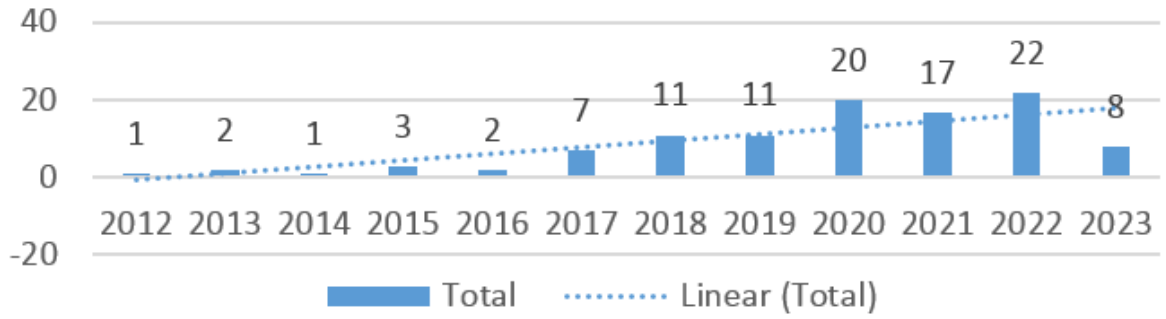

Figure 2. Trendline of Journal Publications Each Year

The results of the search from these 105 articles have been categorised based on the number and Scopus Quartile ranking, as shown in Table 2. There is 74 per cent of the total articles indexed in Scopus and classified in Quartile 1. Furthermore, 16 percent are in Quartile 2, 8 percent in Quartile 3, and 1 percent in Quartile 4. This mapping reflects that this research field has become a globally significant topic and requires further in-depth research in the future.

***Table 2**. Publisher and Quartile*

Journal dan (Quartile)	Total
(Q1) Sustainability	26
(Q1) Energies	4
(Q1) Journal of Cleaner Production	3
(Q1) Journal of Open Innovation: Technology, Market, and Complexity	3
(Q1) Journal of Knowledge Management	2
(Q1) Business and Information Systems Engineering	2
(Q3) IOP Conference Series Materials Science and Engineering	3
(Q1) Craft Research	2
(Q1) International Journal of Design	2
(Q1) Resources, Conservation and Recycling	2
(Q1) Amfiteatru Economic Journal, Asian Economic and Financial Review, Business Horizons, Chemical Engineering Journal, Design Science, Ecological Economics, Entrepreneurship Theory and Practice, Environmental Science and Pollution Research, Fashion and Textiles, Fashion Practice, Foresight and STI Governance, Information Systems Frontiers, Information Systems Journal, International Journal of Innovation Science, Journal of American Folklore, Journal of Innovation and Entrepreneurship, Journal of Intelligent Manufacturing, Journal of Material Cycles & Waste Management, Journal of Small Business & Enterprise Development,	32*

Journal of Sustainable Development of Energy, Water & Environment Systems, Long Range Planning, Management Review Quarterly, MIS Quarterly, Production Planning and Control, Resources, Revista de Estudios Sociales, Software and Systems Modeling, Sustainability: Science, Practice and Policy, Sustainable Production and Consumption, Technological & Economic Development of Economy, Technovation, The Journal of Strategic Information System,	
(Q2) Communications of the Association for Information Systems	2
(Q2) Technology Innovation Management Review	2
(Q2) Archives of Design Research, Cogent Business and Management, Cogent Social Sciences, Foresight, Future Internet, Information Systems and eBusiness Management, International Journal of Emerging Markets, Journal of Environmental and Public Health, Journal of Industrial and Production Engineering, Journal of Industrial Engineering and Management, Journal of Information Systems Education, MIT Sloan Management Review, Procedia CIRP,	13*
(Q3) International Journal of Mechanical Engineering and Robotics Research	2
Forest Products Journal, Frontiers in Psychology, Trziste	3*
(Q4) IOP Conference Series: Earth and Environmental Science	1*
19th International Conference on Sustainable Innovation - Copenhagen, Denmark	1
Total	105

Note: (*) each has one article.

Exploration of Materials in the Context of Upcycling

This research has identified 20 reference articles from 105 selected articles after the selection process. The main focus of these references is the discussion of upcycling (U). The data processing of reference materials was carried out using the NVivo 12 Pro application, applying the STRING technique to conduct literature searches. The results of this data processing (Table 3) show a percentage value for the 15 most covered articles discussing the topic of upcycling.

***Table 3**. Results of References and Percentage Coverage of the Upcycling Code*

No	Focus	References	Coverage
1	*Material Circulation and Designing Process* [42]	176	2.18%
2	*Scaling up upcycling - Community event* [35]	118	1.79%
3	*Scaling up upcycling businesses –case in the UK* [7]	202	1.33%
4	*Upcycling in the Highly Industrialised West* [40]	170	1.31%
5	*Closing the Loop through 'Waste Upcycling* [24]	207	1.16%
6	*Factors Influencing Upcycling for UK Makers* [37]	295	1.13%
7	*Scaling Up UK Upcycling* [36]	201	0.98%
8	*Scaling up UK Fashion Upcycling Businesses* [38]	108	0.91%
9	*Reconnecting people and materials* [6]	81	0.59%
10	*Exploring the Possible Determinants of Upcycling* [34]	33	0.56%
11	*Behaviour Change: The UK Upcycling Case* [39]	65	0.55%
12	*Eco-artist and designer through craft upcycling* [2]	25	0.54%
13	*Circular fashion: integrating upcycling* [43]	60	0.50%
14	*Digital Craft and Upcycling* [44]	13	0.30%
15	*Buying Intention of Upcycled Fashion in China* [45]	37	0.20%

Upcycling represents an advanced and reliable system for creating reusable products within a sustainable cycle. Research conducted by [42] in Korea resulted in an iterative upcycling design process model that drives the subsequent stages in the material cycle after the initial recycling as a generation of upcycled products. Material recovery practices emphasise the importance of initial design and process innovation in industries to achieve upcyclability and a high level of safety.

However, in the commercial aspect of upcycling, the focus needs to be on specific sectors and products [2]. For example, the UK's craft industry focuses on upcycling businesses and involves creative entrepreneurs and households with smaller-scale production and facilities [7]. Reusing local materials involving creative entrepreneurs and households in the material reuse process offers more benefits than large-scale circular material flows. The goal is to accelerate circular material flows and reduce environmental impacts from transportation, processing, and recycling [6].

Material exploration in the context of upcycling is a crucial step toward a more sustainable economy. Upcycling presents significant business opportunities in various craft industries. As a form of creative Art and craftsmanship, it can maximise the value of existing materials by transforming them into high-value new products. However, strong innovation is required to explore materials for initial product design and develop sophisticated systems to achieve optimal results.

Concept of Product Circularity within the Circular Economy

This research identified 20 reference articles from the 105 selected research articles, explicitly focusing on the Circular Economy (CE). This selection was made through data code reference analysis using the STRING technique for the literature search. The results, highlighting the most significant percentage coverage, encompassed 15 articles discussing CE, as shown in Table 4.

***Table 4**. Results of References and Percentage Coverage of The Circular Economy Code*

No	Title	References	Coverage
1	*Circular Economy Research in Finland* [11]	322	2.16%
2	*Circular Economy Business Models in the SME* [46]	415	1.94%
3	*The Circular Economy – A New Sustainability* [3]	271	1.47%
4	*Perceptions of circular business models in SMEs* [47]	177	1.45%
5	*Circular Economy Innovation - Sustainable* [48]	177	1.20%
6	*Collaboration Advances Circularity* [49]	262	1.14%
7	*Materials Flow by Integrating Circular Economy* [23]	208	1.09%
8	*Circular Objectives and Design Strategies* [50]	243	1.02%
9	*Conceptualising the circular economy* [51]	208	0.95%
10	*Social Life Cycle Impact of Products* [52]	208	0.87%
11	*circular - design practice across industrial design* [53]	283	0.87%
12	*Product-Level Circularity Strategies* [54]	153	0.82%
13	*Linking Eco-Innovation and Circular Economy* [55]	134	0.82%
14	*Product design and business model strategies* [56]	132	0.76%
15	*Circular Economy - Concept and Limitations* [21]	143	0.69%

The success of the circular economy is reflected in the three main pillars of sustainable development: environmental, economic, and social. The concept of the circular economy needs to adapt to natural ecosystem cycles and incorporate them into the economic cycle while maintaining a balanced reproductive rate [21]. Potting et al. (2017), as cited in [46], have identified areas where the circular business model can be applied by placing specific types of activities in a hierarchy (referring to the waste management hierarchy) from the least preferred behaviours in the circular concept to those most consistent with the idea. [22], outlines the principles of the circular economy in Indonesia, which consist of three main parts within the 9R framework: (1) developing and using products smarter, (2) extending the lifespan of products, and (3) deriving benefits from the materials used.

Product circularity within the circular economy framework represents a crucial approach to sustainable development. By emphasising the reuse of local materials, maximising the value of existing materials through upcycling, and involving the active participation of the community in the product cycle, this concept aims to reduce environmental impact, accelerate the circular material flow, and sustain economic growth. Thus, product circularity within the circular economy framework is key in addressing sustainability challenges and creating a more sustainable economy.

Aspects of Product Sustainability Through Sustainable Value Creation

This research identified 20 reference articles from 105 selected articles, with a focus on discussions related to Sustainable Value Creation (SVC). This process was carried out by processing data using the code references technique. The results of the percentage coverage of the top 14 articles discussing SVC can be seen in Table 5 below.

***Table 5**. Results of References and Percentage Coverage of the Sustainable Value Creation*

No	Focus	References	Coverage
1	*Design Management in the Creation of Sustainable Business* [28]	140	1.02%
2	*Creativity for Sustainability* [27]	103	0.64%
3	*Closing the Loop through 'Waste Upcycling'* [24]	95	0.52%
4	*The circular economy and the Green Jobs creation* [57]	83	0.49%
5	*Digital Transformation - Business Innovation* [12]	161	0.48%
6	*The Circular Economy – A New Sustainability* [3]	62	0.45%
7	*Innovation in traditional handicraft - sustainable* [58]	102	0.44%
8	*Circular Economy - Concept and Limitations* [21]	83	0.44%
9	*Digital Sustainability and Entrepreneurship* [59]	114	0.40%
10	*User Strategies - Product Lifetimes - Circular Design* [60]	99	0.38%
11	*Cross-cultural collaboration - global value chain* [61]	100	0.34%
12	*circular - design practice across industrial design* [53]	78	0.25%
13	*Collaboration Advances Circularity* [49]	61	0.24%
14	*Explorative Study of Circularity Practices* [62]	36	0.20%

Support from business management for Small and Medium Enterprises (SMEs) in adopting sustainable and circular business models encourages entrepreneurs to pay attention to issues related to Sustainable Development Goals (SDGs). The connection between sustainable development and customer value is reflected in the redesign of business models, where sustainable development value becomes a value proposition for customers. Sustainable policy standards and the implementation of SDGs within companies are also considered value propositions [28]. Meanwhile, mechanisms to promote sustainable value creation require the application of the 6R elements (reduce, reuse, recycle, recover, redesign, remanufacture) as part of circular economic development [5].

In conclusion, regarding product sustainability through sustainable value creation, business management support for SMEs in adopting sustainable and circular business models allows entrepreneurs to address Sustainable Development Goals and create sustainable value for customers. These are important steps in achieving product sustainability and a more sustainable economy overall.

Innovation and Digitalisation in the Context of Product Design Development

Data analysis using reference coding methods was used to provide an overview of Product Design and Innovation (PDI) in the selected 20 articles in this research. The results of the percentage coverage are shown in Table 6 below.

***Table 6**. Results of Percentage Coverage of the Product Design and Innovation Code*

No	Focus	References	Coverage
1	*Digital Innovation Management* [32]	474	2.75%
2	*Digital technology - digital innovation* [63]	260	1.88%
3	*Strategy - digital product and service innovation* [20]	182	1.78%
4	*Building innovation and competitiveness* [64]	194	1.66%
5	*Theoretical background of innovation* [65]	261	1.52%
6	*Innovation in traditional handicraft - sustainable* [58]	334	1.43%
7	*Linking Eco-Innovation and Circular Economy* [55]	187	1.43%
8	*Sustainability Innovation in the Textile Industry* [66]	233	1.43%
9	*User Strategies - Product Lifetimes - Circular Design* [60]	298	1.34%
10	*Sustainable Education and Open Innovation* [67]	187	1.27%
11	*The digital innovation hub* [68]	198	1.08%
12	*Challenges, Open Innovation* [18]	187	0.96%
13	*Material Circulation and Designing Process* [42]	89	0.90%
14	*Circular Objectives and Design Strategies* [50]	225	0.88%
15	*Product design and business model strategies* [56]	136	0.79%

In product design development, sustainability factors are closely related to sustainable innovation, leading to a circular business model through a product design approach. The results of [56] resulted in the creation of a strategic framework aimed at providing guidance for designers and professionals in business strategy to transition from a linear economic model to a circular economy. Product design within the circular economy concept involves various stakeholders and sectors with diverse definitions of goals and strategies, both at the national and international levels, which can limit a shared understanding [50]. Design strategies, especially in the context of the product life cycle, serve as a means to achieve circular principles.

Digital innovation has transformed the paradigm of product design development by introducing concepts of Sustainability and circular economy. This has resulted in business model strategies that focus on extending the product life cycle and resource reuse. Through a circular design framework, industries and designers can plan product lifespans more effectively, understand the interaction between business and products in the supply chain, and move toward a more sustainable future.

Transformation through Digitalization and Technology Implementation

Data processing using the reference code method with NVivo 12 Pro was used to review "digital transformation" (DT) in the 20 selected articles. The results, as shown in Table 7 below, indicate the percentage coverage of the top 15 articles discussing DT.

***Table 7**. Results of Percentage Coverage of the Digital Transformation Code*

No	Focus	References	Coverage
1	*Digital Transformation Process* [69]	348	2.95%
2	*Embracing Digital Technology* [14]	274	2.84%
3	*Digital Disruption* [70]	220	2.31%
4	*Capabilities for digital transformation* [71]	747	2.24%
5	*Digital technology - digital innovation* [63]	394	2.13%
6	*Digital transformation - future research* [16]	802	2.00%
7	*Digital Transformation - Business Innovation* [12]	367	1.79%
8	*Strategy - digital product and service innovation* [20]	228	1.66%
9	*Digital Strategy in Information Systems* [72]	458	1.61%
10	*Understanding Digital Transformation* [17]	570	1.38%
11	*Digital Innovation Management* [32]	256	1.08%
12	*Digital Technology Entrepreneurship* [73]	66	0.68%
13	*The digital innovation hub* [68]	76	0.34%
14	*disruptive digital innovation* [74]	68	0.32%
15	*Disruptive Technologies* [75]	141	0.30%

Digital transformation involves three main aspects: navigating the innovation ecosystem, redesigning internal structures, and enhancing digital maturity [71]. Digital technology has fundamentally altered the landscape of innovation management, requiring researchers to understand the impact of digital elements on the innovation process [32]. Digital technology-driven innovation brings together various stakeholders, such as industry players, organisations, and communities, to drive digital transformation. The organisation's competencies in digital transformation must be precisely aligned with the company's mission, vision, and strategy. This is necessary to achieve the targets management sets and ensure digital maturity that supports competitive advantage in the digital era. Transformation through digitisation and technology application affects innovation navigation, internal restructuring, and digital maturity. Collaboration among stakeholders, especially in the industry, is critical. The ability to identify digital gaps and digital development is crucial. Government support in this transformation process is essential, and organisation-focused competencies support competitive advantage in the digital era.

This study resulted in a mapping of 105 research articles referencing theoretical foundations and previous studies related to various variables, such as the Craft Industry (SMEs), Upcycling (U), Sustainable Value Creation (SVC), Product Design and Innovation (PDI), Circular Economy (CE), and Digital Transformation (DT). This mapping aims to provide deeper insights into future research needs regarding developments, trends, and critical aspects in these fields. The mapping was conducted using NVivo 12 Pro, based on the percentage of codes for each topic (U; Uc; CS; Css; SVC; PDIM; CE; DT) as variables, with the formula: (number of codes in each variable) / (total number of codes) x 100%. As shown in Table 8 below.

***Table 8**. The percentage for each discussion topic*

Variable description:
U = Upcycling
UC = Upcycling Characteristics
CS = Crafter Stakeholder
SVC = Sustainable Value Creation

CSs = Craft-SMEs

PDI = Product Design & Innovation
CE = Circular Economy
DT = Digital transformations

No	Topic and Reference	Coverage of discussion in percentage								Total
1	Circulation Designing Process [42]	19	34	1	0	4	22	13	7	100
2	Circularity Strategies [54]	0	0	1	1	33	22	39	5	100
3	Design and manufacturing industry [76]	0	0	4	24	25	10	12	26	100
4	Circular Economy SME [77]	0	0	5	9	14	11	50	11	100
5	Designing for circular fashion [43]	14	27	1	4	4	16	29	5	100
6	Co-creators in innovation ecosystems [78]	0	0	7	2	20	30	5	35	100
7	Combining craft and digital practice [79]	0	0	6	19	9	27	7	32	100
8	Product design and business model [56]	0	22	1	1	13	24	33	6	100
9	Getting Participatory Design [80]	0	0	33	3	10	18	12	23	100
10	Creativity, Innovation, Sustainability [81]	0	0	1	1	8	42	8	40	100
11	Circular Economy Business Models [46]	0	0	1	3	10	17	64	5	100
12	Creative upcycling [6]	22	0	4	3	8	15	44	4	100
13	Waste Upcycling [24]	19	30	2	3	9	10	23	4	100
14	Create a sustainable creative industry [82]	0	0	13	6	14	33	1	32	100
15	Circular business models in SMEs [47]	1	29	1	4	14	9	38	4	100
16	Disruptive digital innovation [74]	0	0	5	8	7	19	10	50	100
17	Artisans and Designers [83]	0	0	41	8	12	12	19	8	100
18	Sustainable Education Open Innovation [67]	0	0	4	30	10	25	3	28	100
19	Potential areas for design [84]	0	0	14	21	21	20	7	16	100
20	The digital transformation of SMEs [68]	0	0	7	6	8	25	14	40	100
21	Redesign and upcycling [85]	5	31	0	13	10	12	23	5	100
22	Digital Strategy in Information Systems [72]	0	0	6	2	4	10	4	74	100
23	Collaboration Advances Circularity [49]	0	0	23	3	16	11	39	8	100
24	Rethinking Sustainability [86]	0	0	1	0	8	3	88	1	100
25	Innovation in services in SMEs [65]	0	0	3	12	9	35	9	33	100
26	Model for the digital development of SMEs [87]	0	0	9	20	18	7	9	37	100
27	Circular is current design practice [53]	1	0	8	3	18	17	43	10	100
28	Sustainability and Creativity [88]	0	0	3	0	40	18	12	28	100

No	Topic and Reference	Coverage of discussion in percentage								Total
29	Sustainable Competitive Advantage [89]	0	0	5	17	16	21	15	26	100
30	Sustainable fashion businesses [90]	0	0	22	24	26	11	7	9	100
31	Circular Economy [21]	1	3	21	1	18	13	37	5	100
32	Building innovation competitiveness [64]	0	0	1	7	7	39	7	39	100
33	Designing Immortal Products [91]	0	0	3	2	13	30	41	10	100
34	Big Data Ecosystem Model for SMEs [92]	0	0	5	14	14	11	19	37	100
35	Embracing Digital Technology [14]	0	0	5	2	1	3	10	79	100
36	Design Strategies for Circular Economy [50]	0	0	1	1	10	33	50	4	100
37	Sustainable and Business Performance [93]	0	0	14	8	25	15	28	11	100
38	The Circular Economy New Sustainability [3]	0	0	2	2	21	7	62	7	100
39	Digital Sustainability Entrepreneurship [59]	0	0	6	3	30	8	17	37	100
40	Implementing Disruptive Technologies [75]	0	0	13	3	1	8	15	59	100
41	Digital Technology Entrepreneurship [73]	0	0	1	1	2	14	11	71	100
42	Digital transformation in SMEs [94]	0	0	8	2	12	6	15	56	100
43	Models for the digital transformation [95]	0	0	3	3	8	8	3	76	100
44	Circular Conceptual Design [60]	5	24	1	1	13	39	13	5	100
45	Upcycled Fashion Design Production [96]	0	0	4	2	32	25	10	27	100
46	Sustainability Innovation [66]	0	0	3	13	9	31	18	27	100
47	Woodworking Industry [97]	0	0	1	21	4	8	61	5	100
48	Current Status of Circular Economy [11]	0	0	4	0	5	6	82	2	100
49	Integrating Circular Economy Principles [23]	0	0	1	4	10	18	62	6	100
50	Circular Economy Innovation [48]	0	0	5	1	20	13	49	13	100
51	Sustainability Issues in Supply Chain [98]	0	0	13	36	21	11	12	8	100
52	Digital Transformation Process [69]	0	0	3	1	3	15	9	69	100
53	Technological of Circular Economy [5]	0	0	1	1	29	19	42	8	100
54	human resources, culture, and product [99]	0	0	2	19	19	41	17	3	100
55	Circular Economy Practices [100]	0	0	2	22	9	7	48	11	100
56	Digital technology, digital capability [63]	0	0	1	1	2	24	3	68	100
57	Conceptualising the circular economy [51]	0	0	2	1	21	6	67	3	100
58	Sustainable Business Models [28]	0	0	2	2	44	8	38	7	100
59	Definition of digital transformation [15]	3	10	5	3	6	10	3	60	100
60	Development of Sustainable Creative [101]	4	28	2	2	4	17	31	12	100

No	Topic and Reference	Coverage of discussion in percentage								Total
61	Strategic Alignment in SMEs [13]	0	0	15	30	13	8	19	15	100
62	Sustainability and Green Innovation [102]	0	0	4	4	16	34	10	32	100
63	Moving towards Sustainability [103]	0	0	3	2	15	32	30	19	100
64	Portuguese Craft Industry [104]	0	0	10	18	10	26	5	31	100
65	Cultural Sustainability [105]	0	0	43	1	27	11	3	14	100
66	Digital Transformation Strategies [106]	0	0	2	1	9	3	4	82	100
67	Downcycling and Upcycling [107]	6	0	2	3	15	15	52	7	100
68	Digital transformation: a review [16]	0	0	3	3	8	11	8	67	100
69	Digital Innovation Management [32]	0	0	3	0	3	33	8	53	100
70	Achieving Green Innovation [108]	0	0	5	4	8	37	9	37	100
71	Digital innovation strategy [20]	0	0	2	2	4	27	2	62	100
72	From Silk to Digital Technologies [109]	1	0	7	13	24	21	13	22	100
73	Digital Craft and Upcycling [110]	8	0	2	6	6	26	24	29	100
74	Eco-Innovation and Circular Economy [55]	0	0	2	1	13	27	32	24	100
75	Cross-cultural collaboration [61]	0	0	15	15	22	19	9	21	100
76	Materials informatics [111]	1	0	8	4	9	33	30	15	100
77	Open Innovation, at Craft SMEs [18]	0	0	4	27	5	27	8	30	100
78	Enterprise data science strategy [112]	0	0	9	10	16	10	18	37	100
79	Creativity for Sustainability [27]	1	13	4	1	27	19	7	29	100
80	Green information technologies [113]	0	0	13	8	17	9	39	13	100
81	Innovation in traditional handicrafts [58]	0	0	3	9	19	31	9	29	100
82	Scaling up upcycling businesses [7]	37	32	2	2	7	9	11	1	100
83	Recycle management and processing [114]	0	0	0	1	4	20	58	17	100
84	Explorative Study Circularity Practices [62]	0	0	1	2	28	13	54	2	100
85	Digital Disruption [70]	0	0	1	3	7	19	1	69	100
86	The circular economy and creation [57]	0	0	4	1	36	6	48	5	100
87	Scaling Up UK Upcycling [36]	37	11	5	5	10	8	14	10	100
88	Scaling up upcycling [115]	31	38	5	3	9	5	9	1	100
89	Individual upcycling practice [34]	15	27	4	3	13	15	13	9	100
90	Designer through craft-based upcycling [41]	14	36	3	18	5	10	10	4	100
91	Factors Influencing Upcycling [37]	34	38	3	3	10	3	7	2	100
92	The UK Upcycling Case Study [39]	25	32	5	4	12	11	4	7	100
93	Scaling up upcycling businesses [8]	23	33	2	5	7	14	14	3	100

No	Topic and Reference	Coverage of discussion in percentage								Total
94	Predictors of Upcycling [40]	35	40	0	2	6	4	11	2	100
95	circular economy practices [116]	0	0	4	11	12	10	57	6	100
96	Social Life Cycle Impact of Products [52]	0	0	3	4	17	12	61	2	100
97	Exploring Craft-Design Collaborations [117]	0	0	19	35	11	18	5	12	100
98	Participatory design [118]	0	0	55	1	4	18	2	20	100
99	Digital Transformation of Business [12]	0	0	1	6	20	11	6	56	100
100	Understanding digital transformation [17]	0	0	0	5	0	0	0	95	100
101	Outcomes of Co-Designing [119]	0	0	36	19	14	15	1	15	100
102	Digital transformation [71]	0	0	5	2	5	12	5	69	100
103	Barriers to Innovation Development [120]	0	0	2	16	8	35	4	36	100
104	Upcycled Fashion Products [45]	31	24	0	4	14	9	14	4	100
105	Waste upcycling circular economy [121]	6	19	1	1	8	13	44	9	100
	Average coverage in percentage	4	6	7	7	13	17	22	24	100

Table 8 shows that the total for each variable varies, with the DT variable having the highest percentage at 24%. Meanwhile, the U and Uc variables have the lowest percentages, at 4% and 6%, respectively. The analysis of these 105 articles concludes that upcycling has characteristics that have yet to be extensively studied. On the other hand, digital transformation has received more attention. Still, only one article addresses the relationship between upcycling and digital transformation, accounting for only 12% of the codes. This indicates significant potential for further research in this area.

The results of topic coverage in percentage for each variable (Table 8) can be used to analyse the correlation matrix among the variables using the Minitab application. Based on the provided correlation matrix, the correlation between Upcycling (U) and Digital Transformation (DT) is -0.343 (Figure 3). This indicates a strong negative correlation between Upcycling (U) and Digital Transformation (DT). The correlation matrix results are depicted as a Correlogram in Figure 3 below.

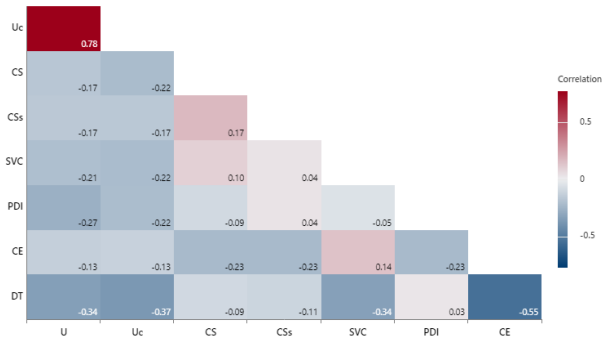

Figure 3. Correlation matrix of coverage in percentage between variables U, SVC, PDI, CE and DT

In this context, a higher percentage of Upcycling corresponds to a lower rate of Digital Transformation. This implies that a greater emphasis on Upcycling tends to reduce the level of implementation of change in Digital Transformation. This may suggest that in the researched literature, there needs to be more studies that deeply investigate how Upcycling and Digital Transformation can mutually support or impact each other in the context of the crafts industry. Hence, there is significant potential for further research to bridge this knowledge gap and better understand the relationship between Upcycling and Digital Transformation in various aspects such as Circular Economy, Product Design and Innovation, and Sustainable Value Creation.

This study also compared the number of relevant articles for each discussion topic as variables (Table 8). A Venn diagram, as seen in Figure 4, was used to create a visual representation of the variables regarding the relationships between the research articles.

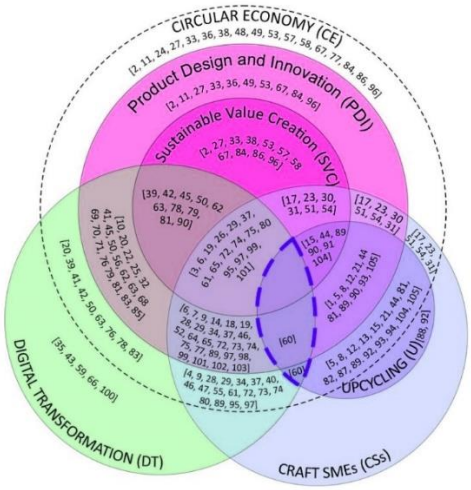

Figure 4. Venn diagram illustrating the relationships of the discussions in 105 previous research articles

This Venn diagram illustrates the relationships between each of the discussion topics, including Upcycling (U), Digital Transformation (DT), Circular Economy (CE), Product Design and Innovation (PDI), and Sustainable Value Creation (SVC). From this Venn diagram, it can be concluded that there is an empty gap indicating a lack of research conducted on Upcycling (U) in conjunction with Digital Transformation (DT) in various aspects such as Circular Economy (CE), Product Design and Innovation (PDI), and Sustainable Value Creation (SVC). This suggests potential for further research in this area.

CONCLUSION

This research conducted a comprehensive literature review involving 105 diverse sources related to the upcycling-based crafts industry. Based on this literature review, several key conclusions can be drawn:

- There is a high level of interest in research on upcycling and the circular economy. This reflects an increased awareness of creating added value from unused materials and extending sustainable material cycles.
- **Lack of research on Product Innovation and Design**: Innovation in product design and development is crucial in the context of upcycling. This innovation involves the use of new

technologies, sustainable product design, and creative crafting methods. Integrating design concepts that consider aesthetics, functionality, and environmental impact has become a primary focus in creating superior products.

- **Digital Transformation as a Driver**: Digital transformation has become a significant factor in advancing upcycling practices. Integrating digital technology into the design, production, and distribution processes can significantly contribute to product efficiency and quality.
- **Sustainability and Value Creation**: The concepts of Sustainability and value creation have emerged as essential approaches in the upcycling-based crafts industry. Research indicates that upcycling can be a source of sustainable economic and environmental value by reusing materials and reducing environmental impact.
- **Potential for Further Research**: Despite significant research in this area, there still needs to be a knowledge gap connecting upcycling and digital transformation. Further research is needed to delve deeper into how digital transformation can support upcycling practices in the context of the crafts industry.

Overall, this research provides valuable insights into the potential and challenges of developing an upcycling-based crafts industry. This research can guide the industry's development toward more sustainable and innovative practices by understanding the roles of innovation, digital transformation, Sustainability, and product design.

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