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"Exploring Design for Manufacturing, Assembly, and Reliability in Product Redesign: Insights and Research Gaps"

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Abstract

In order to remain competitive, the manufacturing sector must constantly introduce new goods to cater to changing customer lifestyles. Redesigning an existing product with the goals of making it more reliable, cheaper, and more satisfying for customers might lead to the creation of a brand-new product. One method of developing products and processes simultaneously is known as Design for Manufacturing and Assembly (DFMA). This method prioritizes reducing costs by taking manufacturing and assembly ease into account. In the early stages of design, product dependability is just as important as manufacturability. Loss of market share and astronomical costs might result from defective goods. The major goal of this research is to draw conclusions from existing literature and suggest avenues for further investigation into product redesign using DFMA and DFR as an integrated framework. The goal is achieved by conducting a literature review using bibliometric analysis, which is informed by the articles found in the Scopus database. This study examines and discusses present and previous DFMA and DFR for product redesign, leading to a systematic evaluation of the last five years. A DFMA-based product redesign paradigm that incorporates reliability prediction into early product design is the subject of future study.

Keywords

Design for Manufacturing and Assembly (DFMA), Design for Reliability, product redesign, review

1. Introduction

Quicker technology advancements, more complicated products, and shorter time to market are all challenges that the manufacturing sector must contend with. As a result, developing new products is essential for maintaining a competitive edge. After a product has been available for a while, one approach to launching a new one is to give it a facelift. Smith, Shen, and Smith (2012). The primary motivators for redesigning a product also include changes in customer wants and requirements. Redesigning a product or its components may fix issues with its current features, capabilities, or production methods (Li, Zhou and Wu, 2020).

Concepts for new products often originate from existing ones. The capacity to carry out its intended purpose, including increased longevity, dependability, and precision of result, is a measure of product quality. As a result, most new product designs are derivative designs, which include modifying an existing approach to meet the demands of the present (Harlalka et al., 2016a; Prabowo et al., 2020). Repurposing existing design information to address new product design challenges accounts for about 75% of engineering design activity (Smith, Smith and Shen, 2012). According to El-Nounu, Popov and Ratchev (2018a) and Chowdary, Richards and Gokool (2019a), redesigning a product may increase its dependability, decrease its cost, increase its life span, and minimise its environmental effect. A key component impacting production expenses is product enhancement. This is why product designers are always looking for new ways to assess manufacturability and other development criteria, such as cost. Redesigning products helped cut down on production costs for IBM, Ford, Toyota, and GM (Geoffrey Boothroyd, Peter Dewhurst, 2010). In order to improve the dependability of their products, Tesla, Apple, Honda, Boeing, and Hewlett-Packard redesigned them (Raheja and Gullo, 2012; Geiger and Motors, 2016).

A more streamlined product development process that nevertheless maintains acceptable quality and competitive costs is required due to the rapid development of technology, particularly in information technology, where the product life cycle is increasing shorter. One way to streamline the production and upkeep of products and services is via the use of concurrent engineering, or CE. According to Karningsih, Anggrahini, and Syafi'i (2015), CE is considered a superior technique for new product design because to its stated advantages, which include a quicker time to market, lower costs, and the best quality. One way to reduce the high cost of rework and the risk of failure is to determine product requirements and production procedures in parallel or jointly (Bowonder and Sharma, 2004). Taking into account every facet of a product (over its lifecycle) right from the start of its design is key to CE's holistic approach. Although just 5% of the entire cost is directly attributable to the design process, Boothroyd (1994a) stresses that it impacts or decides around 70% of that amount. Thus, the overall cost will be significantly reduced as a result of the design process.

From every X vantage point, the X (DFX) method improves product and process design and helps with C.E. implementation. The development life cycle (e.g., manufacturing or assembly) or product attributes (e.g., quality, dependability, environmental effect) denoted by the X in DFX are defined by Holt and Barnes (2010). Measurement of competitiveness, improvement choices in product and process design, decrease of lead time, and reduction of material cost are all DFX advantages. Design for Manufacture and Assembly (DFMA) is one of DFX's methodologies. DFMA's main goal is to minimize the overall cost to build a product by detecting incorrect designs with high manufacturing costs as early as feasible. In his DFA approach for product redesign, El-Nounu (2018) took component operating difficulties, cost, failure analysis, and obsolescence into account. It helps with product design by thinking about the present product's failure mode.

As per Paganin (2017), dependability is the likelihood that a part, tool, system, or procedure will function as intended for a certain period of time under the specified conditions. Design for Reliability (DFR) is another strategy used by DFX. Its goal is to guarantee the dependability of a product's components or system during its entire lifecycle. One idea behind DFR is to design products in a way that makes them more reliable (Mayda and Choi, 2017; Pourgol-Mohammad et al., 2017; Borchani et al., 2019). While redesigning a product, it is important to take client needs into account, which includes making sure the product is more reliable.

Since it has such a profound impact on the following phases of product development and manufacturing, the first conceptual design stage is constantly fine-tuned in product design. Reducing DFMA-based manufacturing time and costs and improving reliability are two areas where product redesign challenges might be difficult to effectively address at the original conceptual design stage. There have been several attempts to address this issue with integrated design models; nevertheless, no success has been recorded in predicting the dependability of product redesign at the early conceptual phases. Here is a rundown of the article's structure. In the second half, the method of research is detailed. We provide a systematic evaluation of current DFMA and DFR methods, as well as the findings of the bibliometric research and the VOS analysis. The essay is concluded in the final part, and subsequent sections suggest areas for further investigation.

2. Research Methodology

This literature review conducts an initial goal of exploring the body of literature and following the related articles in a combination of DFMA, product redesign, and DFR. It uses a systematic literature review (SLR) and bibliometric analysis (B.A.) to organize the data in a more reader-friendly form. SLR explicitly contains information needed to be tailored into some helpful information. This method has been widely used across multiple study fields and representing high volumes of bibliographic (Sulistio, 2015; Paganin and Borsato, 2017; Benabdellah *et al.*, 2019). To achieve the goal of this research, the general data of the articles available in the databases Scopus was considered by using the keyword "design for manufacturing and assembly" and "design for reliability." A method for selection and analysis of the articles is shown in Figure 1.

Next, search for these keywords in the Scopus database with the format: ((TITLE-ABS-KEY ("design for" manufacturing and assembly and product redesign) OR TITLE-ABS-KEY ("design for" X and product improvement) OR TITLE-ABS-KEY ("design for" reliability and product redesign or product improvement)) AND (LIMIT-TO (LANGUAGE, "English"))). Search results are 212 final papers and 1 article in press in the year 2000-2021. The documents have 136 conference papers, 50 articles, three reviews, others in book chapters, and lecture notes. In line with the purpose of our study, we only considered 53 articles and reviews. The articles were scrutinized to see if they should be included in the sample. Only publications with a consistent title in relation to the research's goals and axes were chosen. As a result, 52 items were left for additional investigation. The purpose of reading the abstracts was to determine the major conclusions, goals, applications, and methodology used in each article in order to find the most relevant publications for this research. During the screening process, 36 papers were chosen, with the remaining articles being put on hold for further examination and possible selection. The remaining 14 articles were then chosen and added to the list, resulting in a total of 50 articles for final analysis.

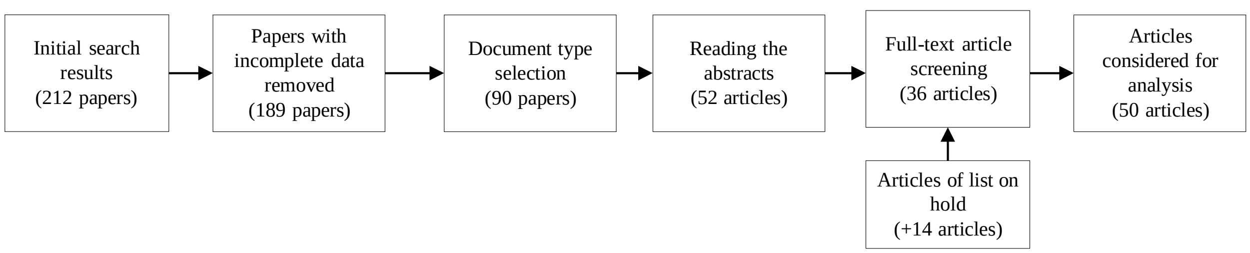

Figure 1. The screening process to select the article sample

This study uses the VOS viewer 1.6.13 edition to provide a graphical depiction of the bibliographic information as a supplement to the analysis. The software creates a visual representation of the network and cluster of documents. The type of analysis employed was co-occurrence, and the unit of analysis was keywords. That is, associations are established based on the quantity of documents that include the keywords in question. The method of counting utilized is full counting. That is to say, each association is equally weighted. Bibliometric analysis is a tool for determining the structure of a network that answers issues like what are the key themes in an area of study, how they relate to one another, and how a given topic evolves over time (Amin, Khan and Zuo, 2019). Bibliometrics can deliver more objective and thorough results, as well as handle massive data sets swiftly and clearly. If items in Figure 2 that the VOS algorithm generates have more references in common, they are closer to one another. It indicates that they share a theoretical standpoint or approach (Marzi *et al.*, 2020). Also, the VOS with network visualization gives 5 clusters. Articles are clustered in the same group are strongly linked as a group, indicating a possible area of research. It highlights the presence of five well-polarized clusters characterized by the following themes:

1) Red cluster: DFA, DFM, DFMA, DFX
2) Green cluster: DFM and mathematical model, CAD/CAE
3) Blue cluster: Cost-effectiveness, reliability, genetic algorithm, quality assurance
4) Yellow cluster: a design for reliability, reliability improvement, risk assessment
5) Purple cluster: concurrent engineering, cost reduction, machine design, manufacturing process, and optimal design

As emphasized by Benabdellah (2019) and Paganin (2017), visualization techniques can be used to simplify research mapping. These techniques have become one of the most reliable approaches in bibliometric network analysis, particularly in mapping and classifying the relationship between journals, co-authoring, researchers, and keyword emergence. When two papers cite the same third work in their references, this is known as bibliographic coupling. The degree of co-authorship among the most productive authors is measured by co-authorship. The degree of citations between two variables is the topic of citation analysis. The most common keywords used by different articles, as well as which terms usually appear below the abstract, are displayed in the co-occurrence of keywords. The terms that appear more frequently in the same papers are visualized using a network connection (Marzi et al., 2020).

3. Metadata Statistical Analysis

The statistical metadata analysis in this study is limited to simple descriptive statistical analysis. Figure 3 exhibits the quantity of annually published papers and the number of citations from 2000 to 2021. It can be observed that research on DFMA and DFR continues to increase. Moreover, the number of papers published in the last five years are 30 papers. In terms of the year of publication, 2019 was the year in which the most articles on those topics were published in the previous five years. Figure 4 shows publication distribution to journals while the number of papers published on this research topic is less than ten papers of each journal. It is still relatively insufficient. Science Journal has the highest citations for leading publication (see Figure 5), while IEEE Trans Reliab has the leading publication by total papers.

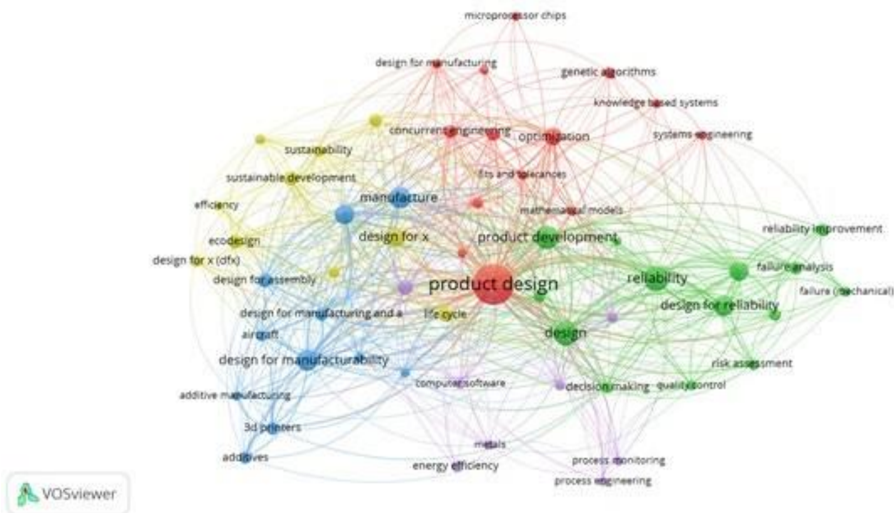

Figure 2. VOS Network Visualization for Bibliometric

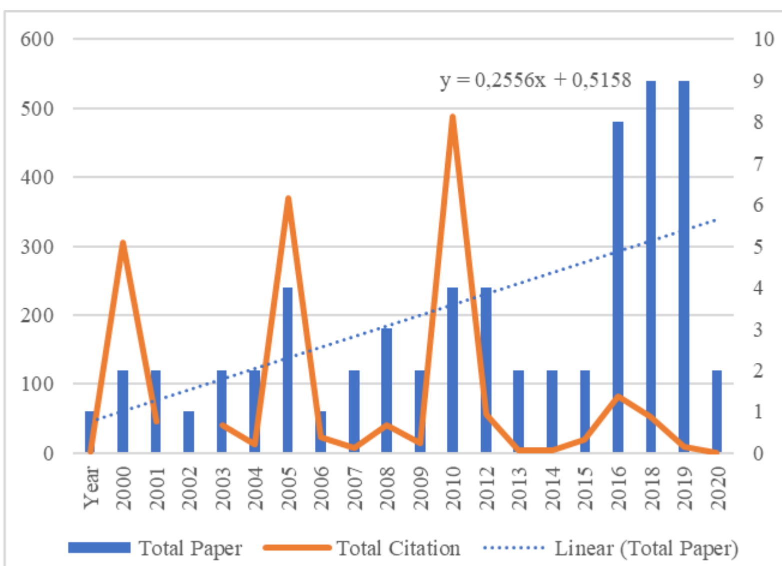

Figure 3. Distribution of papers and citations by year

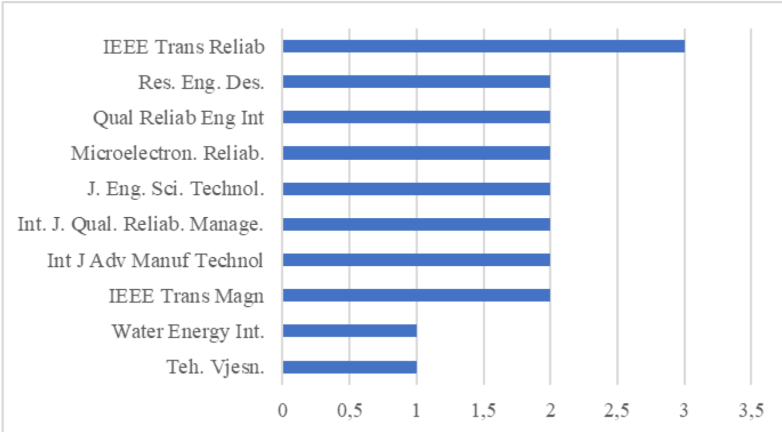

Figure 4. Publication distribution according to the total paper of journals

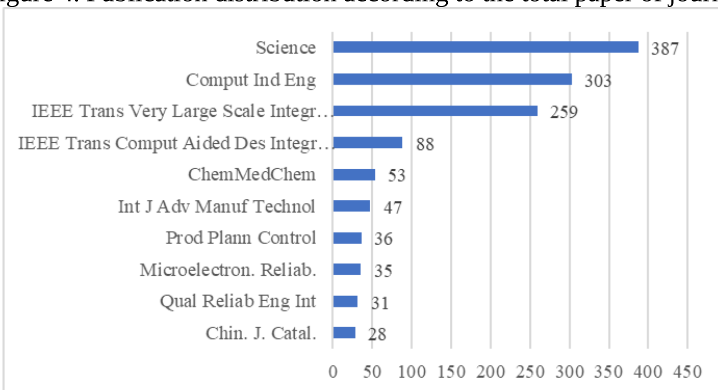

Figure 5. Publication distribution according to total citation of journals

4. Review of Main Concept and Foundations

This section addressed at the conceptual foundations of the DFMA and DFR, as well as how they may be merged into a new product redesign conceptual framework. A methodology for the use of DFMA and DFR in the early stages of product design and its benefits should be adopted in addition to the evaluation scope of conceptual definitions. Demonstrations of certain applications that have already been published in the literature, as well as their major findings, are also provided.

4.1 Design for Manufacturing and Assembly (DFMA)

DFMA is a combination of Design for Assembly (DFA) and Design for Manufacture (DFM). DFMA is used for three main activities (Boothroyd, 1994):

a) As a foundation for concurrent engineering research on structural simplification to save manufacturing and assembly costs.
b) As a tool for analyzing rivals' products and quantifying production and assembly challenges.
c) As a should-cost tool to assist control expenses and negotiate contracts with suppliers.

DFMA provides a more straightforward design structure without leaving customer needs nor compromising the product quality. A simple form of design also balances a shorter assembly time and reduces manufacturing costs. There are many DFA methodologies, but the most widespread are Boothroyd-Dewhurst (B&D) methodology, Lucas methodology, Hitachi-AEM methodology, and Westinghouse methodology. B&D methodology gives four indicators for its implementation: assembly time, assembly cost, the minimum number of component, and design efficiency (Ezpeleta *et al.*, 2019). As for the critical assumptions used in B&D methodology:

a) Parts are added one at a time during assembly.
b) Components are present in bulk and randomly oriented.
c) The designer has complete information on part dimensions.

Lucas's methodology has a scale point related to measuring the difficulty level of assembly processes in their implementation. This method gives three indicators: design efficiency, feeding index, and fitting index (Dochibhatla, Bhattacharya and Morkos, 2017). Dochibhatla (2017) conquered the joint implementation of Lucas and B&D methodologies, as seen in Figure 7. It also underlined the use of the Lucas method in the early phase because this method does not require part dimensions data to result in design efficiency. B&G method is applied later to improve the design with accurate data of design parameters. The implementation resulted in an increase in processing time for designers. Only Lucas methodology fits to implement when details product data is incomplete. Lucas's methodology used to be considered in the conceptual design phase. While in the detailed engineering design phase, it would be considered to use B&D, Hitachi, or Westinghouse method.

Chowdary et al. (2019) discovered that DFMA tools can save time when evaluating designs and that they should be used early in the design selection process. As the original design is evaluated, revised, and redesigned work is conducted for the product evaluation, Ahmad et al. minimize the product cost water nozzle by implementing DFMA approach. Jaime Mesa et al. (2018) investigated sheet metal enclosure device design for assembly and manufacturing (DFMA). The methodology used in this study to determine the step of DFMA standards linked to sheet metal enclosures, as well as sustainability indicators that provide manufacturing and design advice, was integrated with this strategy to establish a sustainable approach.

The objective of DFMA is to reduce product structure to make assembly easier and to enhance components to make manufacturing easier. It also enables designers to reduce the number of components used, simplify and reduce the number of manufacturing procedures, use standard parts and materials, design for efficient joining, part production, and assembly, and use common parts across product lines, as well as eliminate or reduce the amount of adjustment required. Table 1 summarizes the influence of various researchers towards the DFMA framework based on integrated product design.

Table 1. Contribution researchers to DFMA area and its integration design approach

Research Study	Contribution to the field
(Cakir and Cilsal, 2008)	To assist designers in refining their designs according to DFM principles, a DFM matrix-based access tool was developed using the theory of innovative problem solving (TRIZ).
(Emmatty and Sarmah, 2012)	DFMA and platform-based design provide an integrated conceptual product development framework. For a specific application in aircraft design and production, the DFMA approach was used.
(Barbosa and Carvalho, 2013)	The DFMA approach was used to develop a food processor in order to reduce manufacturing costs.
(Harlalka *et al.*, 2016a)	Developing a model of manufacturing cost reduction through DFMA methodology to redesign a food processor
(Thompson, Juel Jespersen and Kjærgaard, 2018)	In high-speed product development contexts, DFMA can be beneficial in reducing late engineering changes (E.C.s), according to an industrial case study.
(Volotinen and Lohtander, 2018)	DFMA concepts were used to redesign a ventilation unit in this case study.
(Pinzon, Lascano and Maury-Ramirez, 2012)	Integration of DFMA with CAE programs to decrease manufacturing costs, shorten time to market, and enhance the quality of mechanical system design deliverables
(Tasalloti *et al.*, 2016)	Weld design and analysis using an integrated DFMA–PDM (product data management) model that can be utilized with CAD programs.
(Ginting and Ali, 2016)	Combining TRIZ, DFMA, and QFD, this examination gives an in-depth analysis of identifying and locating issues of strength, weakness, and results.
(Mesa *et al.*, 2018a)	For sheet metal enclosure devices, a unique way to incorporating sustainability ideas into traditional DFMA methodology has been developed in this article.
(Zhang, Chu and Xue, 2019)	Identification of product aspects that may be enhanced based on internet feedback for product redesign.
(Ezpeleta *et al.*, 2019)	During all phases of product development, a novel DFA approach to enhance assembly has been developed.

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(Butt and Jedi, 2020)	Using the DFMA methodology, this research redesigns the TTC conveyor system for cost and design efficiency gains.

While the DFA approach is being used to redesign the product, another topic that needs to be addressed is the cost-effectiveness of materials and production processes. Cost estimation is the study of predicting expenses associated with a set of activities before they are carried out. Design for Manufacturing and Assembly (DFMA) is a cost-cutting approach presented by Harlalka et al. (2016) for designers to analyze manufacturing components of a product redesign. Various cost-cutting options are identified in the design of a food processor built by a reputable Indian business in this study. The researcher's suggestions are generated to lower the product's overall production cost. According to Favi et al. (2016), developing a multi-objective design method is done in the conceptual design phase of complex product development for a complete examination of the manufacturing factors (assembly, materials, processes, costs, and times). At a conceptual level, the integrated ideas of DFMA and Design to Cost (DtC) are used to select the ideal assembly concept (see Figure 6). The method would aid designers and engineers in determining the most cost-effective design option.

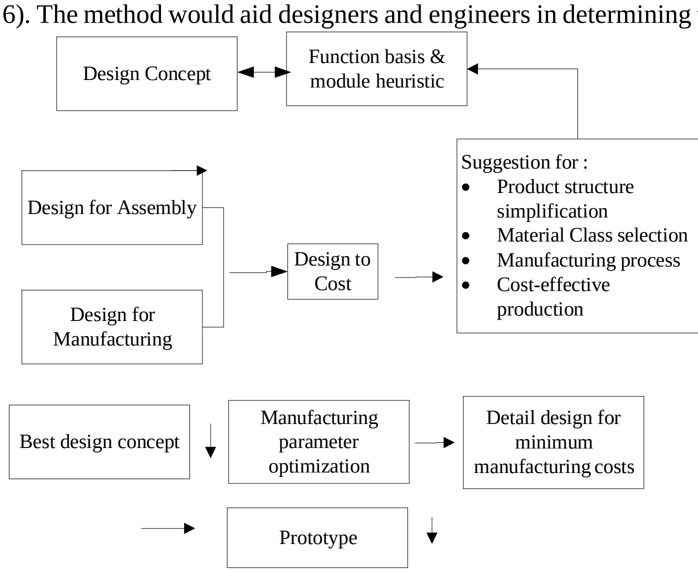

Figure 6. DFMA vs Design to Cost framework (Favi, Germani and Mandolini, 2016a)

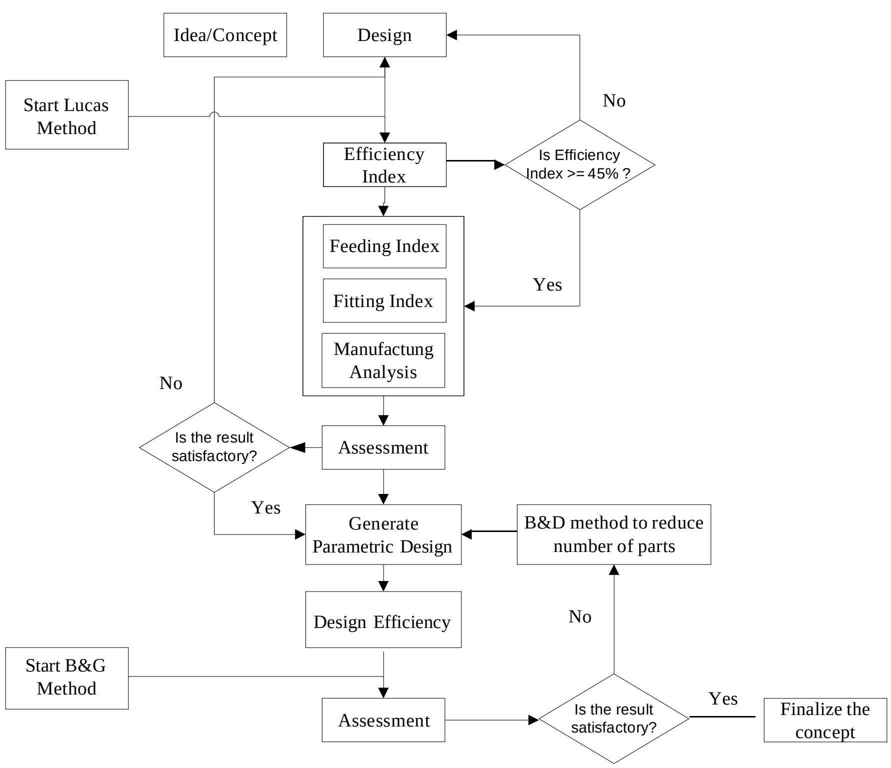

Figure 7. An Integrated of Lucas-B&G method of DFA (Dochibhatla, Bhattacharya and Morkos, 2017)

4.2 Design for Reliability (DFR)

The possibility that a component, tool, machine, system, or process will perform a specific function without failure within a given time period is defined as reliability. The goal of Design for Reliability (DFR) is to design key system functions out of a system (Raheja and Gullo, 2012; Prabowo et al., 2018). The DFR process begins with the development of all products and processes at an early level. It assesses whether any of the idea designs can achieve the derived reliability requirement, as well as uncovering probable failure modes and making design recommendations to mitigate them. DFR will aid in the identification of prototype issues, lowering life cycle costs and field failure rates. The importance of the DFR technique throughout the new product development stage has the advantage of ensuring a product's reliability throughout its life cycle.

From inception until obsolescence, design for reliability is a method that describes a full collection of techniques that aid efforts to improve a product's reliability. The choice of the suitable reliability tool at each stage of product development and implementation is closely related to the success of the DFR application. Because reliability is defined as the probability of failure, the designer must have data on loads and strengths as well as a proper stochastic model in order to evaluate it. If the obtained reliability values are for each usage, then the input data (load and strength) must be precise, which necessitates a careful design (Mayda and Choi, 2017). Reliability becomes a design parameter, and it must be considered early in the product development process. Using a probabilistic approach in product design is a step toward considering reliability and DFR. The strength factor and stress factor are the fundamental assumptions of reliability analysis in probabilistic design methodology (Kapur and Pecht, 2014). Table 2 summarizes different scholars' contributions to the DFR framework based on integrated product design.

Table 2. Contribution researchers to DFR area and its integration design approach

Research Study	Contribution to the field
(Sharp, Andrade and Ruffini, 2019)	Determining since none of the concept designs are capable of satisfying the derived reliability requirement, as well as identifying possible failure causes and making design recommendations to mitigate them. Probabilistic Design and Physics of Failure Analysis are two DFRL approaches used in this article.
(Araujo, 2017)	Presenting the implementation of a failure mode-based product design and manufacturing process review, as well as reducing reliability concerns owing to design flaws, lowering quality costs, and launching a successful new product and process.
(Pourgol-Mohammad *et al.*, 2017)	Based on the DFRL of an automobile system and taking into account its safety-critical component, an integrated approach has been developed. The dependability block diagram approach is used to represent the system, which is then simulated using the Monte Carlo methodology.
(Mayda and Choi, 2017)	This research developed a framework of reliability-based design for early stages of the design process. Proposed framework is effective to achieve reliable design solutions that have uncertain quantitative characteristics to be used further in probabilistic structural analysis
(Khodaygan and Ghaderi, 2019)	For the early phases of the design process, a reliability-based design framework is provided. The proposed framework is useful for achieving trustworthy design solutions with unknown quantitative features, which can then be employed in probabilistic structural analysis.
(Ma, Chu and Li, 2019)	An integrated approach to identify function components for product redesign based on analysis of customer requirements and failure risk
(Borchani *et al.*, 2019)	An integrating model-based system engineering with set-based concurrent engineering principles was developed in this research. This model is developed for reliability and manufacturability analysis of mechatronic products
(Paganin and Borsato, 2017)	Collecting and performing an analysis of the most recent literature of Design for Reliability

5. Discussion

A lot of companies revamp their products to make new ones. Redesigning a product implies creating a new design that improves upon an old one. The creation of a product is made more efficient and of higher quality via redesign. Researchers have developed the Boothroyd and Lucas-Hull DFMA models by considering several factors, such as improved reliability (Smith and Clarkson, 2005; He et al., 2018), performance improvement (Smith and Clarkson, 2005; Gu, Cheng and Qiu, 2019; He et al., 2019; Yin and Hou, 2019), reuse-ability or remanufacture-ability of products (Anguswamy et al., 2013; Chhim, Babu and Sadawi, 2019), increased efficiency (Li, Reimann and Zhang, 2018), improved tolerance (Khan et al., 2018; Wagner, Haefner and Lanza, 2018), increased reliability (Farooq et al., 2017; John, Balachandra Shetty and Mishra, 2018; Lu et al., 2018), ease of maintenance and repair (Desai and Mital, 2006), leanness (Gupta and Kundra, 2012), and design optimization (Al-Shayea et al., 2011; Cheng, Conrad and Du, 2017; El-Nounu

The early design stage to conceptual design accounts for 83% of the potential loss or failure in product planning and development, according to a comprehensive literature study (Benabdellah et al., 2019; Chowdary, Richards and Gokool, 2019a). When redesigning a product to meet customer demand, it may be challenging to include all of the necessary factors into the production process, including manufacturing, material selection, pricing, and dependability planning.

throughout the design and development of new or improved products, during the assembly planning phase. For this reason, it is essential to take advantage of research opportunities that center on creating a product redesign that takes failure risk into account.

Because it has such a profound impact on the product development and manufacturing phases, it is becoming more and more clear that product design improvements must occur within the early stages of the design process. Predicting product dependability effectively at the original design stage becomes increasingly hard for bigger and more complex product sizes. Efforts to forecast dependability in each design choice have fallen short, despite the several design techniques put out to address this issue. Research suggestions for the DFMA model's conceptual development must, therefore, take into account the reliability predictions that may arise in the subsequent technical design phases.

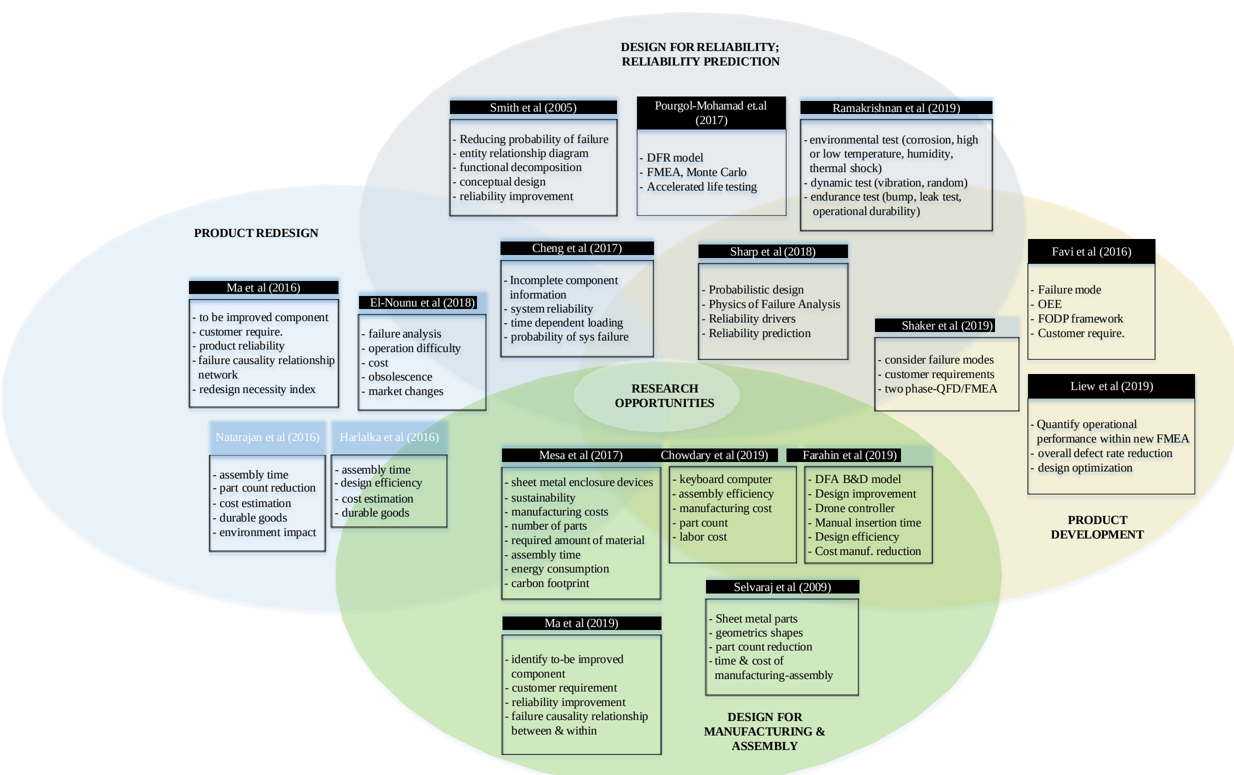

Figure 8. Research Opportunities Map

Ma (2016) developed an integrated QFD-FMEA framework to identify components to be redesigned by considering consumer needs and product reliability. This QFD-FMEA integration can solve deficiencies in the FMEA method so that in determining the priority of critical components to be redesigned, it involves customer needs and technical characteristics supported by the QFD method (Gu, Cheng and Qiu, 2019; Shaker, Shahin and Jahanyan, 2019). Behnke (2018), in his research in the area of failure data and warranty, found cases of how the failure analysis process was carried out with the condition that most of the failure modes had unknown information. Shahin (2004), Madzik (2020), and Tang (2021) developed the Kano-FMEA integration in determining the risk priority of components of a product. Suef et al. (2014) proposed a new way for identifying the VOC using complaints and claims in a product design with QFD-Kano approach. The integration of Kano-FMEA and QFD/FMEA shows that a history of product failure is also considered in product development. The contribution of the two integration models is the determination of the ranking or priority of components and features of the product to be developed by meeting consumer needs and improving reliability. In relatively similar research in product and system reliability predictions, the dependent component in the product structure becomes a priority for obtaining information about environmental conditions and operational conditions. No research discusses the priority use of the components and product features developed at the early design stage. As studied by Ma (2016, 2019), his contribution to the integration of QFD / FMEA in product redesign. In contrast, the development of the Liew et al. (2019) model utilizes the component priority ranking results from the failure analysis in assembly and manufacturing process improvements (DFMA).

Simplification of the structure of assembly and manufacturing products through DFMA aims to reduce manufacturing costs and times (Harlalka *et al.*, 2016; Mesa *et al.*, 2018; Butt and Jedi, 2020; Mandolini *et al.*, 2020). The considerations used in simplifying the structure of the product components in the assembly process are also supported by the ease of manufacture and accommodating the needs and wants of consumers with the support of the Kano-QFD method (Ginting, Ishak and Malik, 2020). Improvement of assembly method is one product redesign benefits (El-Nounu, Popov and Ratchev, 2018). The ease of assembling and manufacturing from the product redesign is expected to increase product reliability. Research by Pourgol (2017) and Mayda (2017) outlines a reliability design framework (DFR) in the product improvement process, especially in the early design stage. The FMEA method takes a significant position in determining the critical components that are decisive in a redesign. Research gaps are open to considerations of reliability in the DFMA framework. Both Pourgol and Mayda have not reviewed the predictions of product reliability when faced with the challenge of downsizing the product component structure. Future research opportunity needs to be completed in the following research as seen in Figure 8.

The DFMA model that considers manufacturing costs at the material planning stage is a significant decision in the Design to Cost framework (Favi, Germani and Mandolini, 2016). It is not up for debate to consider manufacturing costs in assembly design and ease of manufacture. Mandolini (2019) emphasizes that the combination should include a costing model, which is generally applied in the procurement phase, with a design-to-cost model usually implemented at the early design stage. Therefore, proposed research focusing on framework development of design for manufacturing, assembly, and reliability consideration needs to be realized by taking into account manufacturing costs. In improving product design, it is emphasized that it is carried out at the early stage because it significantly affects the product development stage and the production process. However, it is tough for larger and more complex product scales to predict product reliability at the initial design stage accurately. Various design methodologies have been proposed to solve this problem, but efforts to maintain reliability in exploring design alternatives have not been achieved (Goo et al., 2019). Therefore, this study proposes a DFMA development model for conceptual design considering the reliability problems and failure modes that may arise at the successive detailed design stages. This model intends to integrate axiomatic design independence and hierarchical structure from failure modes, effects, and criticality priorities, which are widely used techniques for analyzing product reliability.

6. Conclusion

In their pursuit of ever-increasing customer base and product complexity, companies have been laser-focused on product reinvention as a means to maintain competitiveness. There is a steady push to enhance the product's early conceptual design phase as it has such a profound effect on the development and production phases. DFMA finds inefficient designs with high manufacturing costs quickly and lowers the overall cost of improvement. Reduced field failure rates and life cycle costs may be achieved with the help of DFR in detecting prototype faults. This study compiles a bibliometric overview of DFMA and DFR literature from the years 2000 to 2021. Using the Scopus database, the research examines articles published within the specified time frame. According to the results, distribution publications still fall short, thus more study is required in this area. Meeting client needs, saving manufacturing time and costs, and boosting dependability in an integrated way are all difficult difficulties to overcome when correctly redesigning items from the original conceptual design stage. Important factors to consider when redesigning a product to meet customer needs include product obsolescence, examination of warranty data, user claims, internet reviews, and consumer acceptability. Additionally, there is still a great deal of research development that makes use of the DFMA approach. The DFMA and DFR integrated model would be strengthened by a reverse engineering technique after product redesign. Sustainability, minimal investment, and risk are other tough factors that might be used. A trade-off analysis between various product redesign goals should also be established in future study.

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