A Strategic Support Tool for the Incorporation of Societal Benefits into Toy Design

by

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Finally, I dedicate this thesis to Christ my Lord, God, and saviour who guided and provided for me in my life; to my parents Lawrence and Helen, who have shown me living faith in times of blessing and trial; to Ben and Ruth, for their patience and understanding; and lastly, to Jennifer, who endured this exhausting journey with me, always offering invaluable support and endless love.

This Thesis is but an extension of my humble life following God.

“He has shown you, O man, what is good; And what does the Lord require of you, but to do justly, to love mercy, and to walk humbly with your God?”

The Holy Bible, Micah 6:8

Synopsis

This thesis reports on the research undertaken to embed positive social factors into strategic decision making of toy design and manufacturing. This is achieved by two objectives, the first and main objective of this research is to develop a framework which assess the societal benefits of products and enable the comparison of products based on their functionalities. The secondary objective is to develop a toolkit that incorporates the framework with existing sustainable assessment and product management strategies.

The research reported in this thesis is divided into four major parts. The first part reviews the relevant literature in sustainable development, related governmental sustainable product design tools and methods, and sustainability in the toy industry. Various sustainable design tools, methods, and techniques have also been identified and reviewed. the concept of positive impact of products are further reviewed in the social life cycle assessment method, and in the inherent benefits of toys. Literature reviews have identified a gap of knowledge in the method for assessing social benefits from using a product, and how such information can inform and support strategic and sustainable decisions of toy companies. The second part introduces a societal benefit assessment framework and method which identifies, characterises, and quantifies product functions and benefits. societal benefit is defined as the positive value of product functions that contributes to user values and the subsequent benefits to the wider society. The method is successfully demonstrated through an example of assessment and comparison of two toys. The third part presents the design of a toolkit that implement the societal benefit assessment method and integrate it with other sustainable assessment tools to support strategic product management and design decisions. The toolkit brings together the societal benefit assessment method with environmental assessment and economic perspectives to provide a holistic strategy support for product management and design. Two case studies were carried out to highlight the applicability and usefulness of the toolkit. The case studies are based on a medium size toy manufacturer and a global multi-branded toy corporation.

In summary, the research has concluded that positive impacts of products are not sufficiently assessed and considered in sustainable design methods and assessment tools. The research has highlighted the importance to demonstrate products' societal benefits. A systematic framework to assess societal benefits of product provides a sound methodology to identify and quantify positive impacts of products.

Abbreviations

AHP	Analytical Hierarchy Process
AoP	Area of Protection
CBM	Cost Benefit Matrix
CSR	Corporate Social Responsibility
DfA	Design for Assembly
DfE	Design for Environment
DfR	Design for Recycling
DfS	Design for Sustainability
DfX	Design for X
ELCA	Environmental Life Cycle Assessment
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management System
ERPA	Environmental Responsible Product Assessment
ESE	Environment, Social, and Economic
GPP	Green Public Procurement
IPP	Integrated Product Policy
LCA	Life Cycle Analysis
LCC	Life Cycle Costing
LCI	Life Cycle Inventory Analysis
LCIA	Life Cycle Impact Assessment
OEM	Original Equipment Manufacturer
QFD	Quality Function Deployment
R&D	Research and Development
SBA	Societal Benefit Assessment
SCP/SIP	Sustainable Consumption and Production and Sustainable Industrial Policy
SD	Sustainable Design
SDG	Sustainable Development Goals
SHDB	Social Hotspot Database
SLCA	Social Life Cycle Assessment
SMEs	Small and Medium Enterprise
SPD	Sustainable Product Design
TSD 2009	Toy Safety Directive 2009
WEEE	Waste Electrical and Electronic Equipment Directive

List of Figures

List of Tables

Table of Contents

Chapter 1 Introduction

During the relatively brief period of human civilisation, our planet has supplied us with seemingly limitless amount of natural resources for our needs in all facets of lives. However, the damaging impacts of our consumptions and our ways of life are more apparent since the turn of the 18th century where industrialisations had a rapid rise. Climate change, eutrophication, pollutions, deforestation, biodiversity depletion, ozone depletion, and resource depletion have all became familiar terms and we are experiencing the lasting effects (Carson, 1962). Whilst these issues caused by human activities were raised by activists in the early 60's, it is not until another quarter of a century before it started to be taken seriously by world leaders. One of the first major steps in this process was the establishment of the UN Environment Commission in the 70's, and its first major globally co-ordinated success in reducing the damage to the Ozone layer. This was subsequently followed by the Bruntland Report that set the definition for sustainable development (World Commission on Environment and Development, 1987). In spite of these initial promising gains, global politics has failed to keep pace with the growing body of scientific evidence that points to the need for immediate global action to tackle man-made climate change and our current unsustainable use of earth's natural resources, let alone the pull-out of US's agreement to the latest Paris agreement (BBC News, 2017). With the majority of countries and companies wedded to economic growth as the primary management model, the challenge for sustainable development is therefore, how to achieve this whilst reducing the impacts on the environment?

In manufacturing, sustainability has also been recognised and taken up, initially it was driven by customers and legislation, and it mainly focused on environmental impacts. As the understanding and awareness of the future challenges has grown, other initiatives have emerged such as Zero Waste initiative and Environmental Management Systems (EMS) (European Environment Agency, 2015), however one aspect of sustainable development that has resonated strongly with manufacturing is resource use. This is partly due to global competition and the need to be efficient with energy and resource use (Ernst & Young, 1998). Resource and materials efficient manufacturing is a well-established, profit driven philosophy and method that aims to eliminate waste in all its forms from the manufacturing operation (Womack

et al., 1990). This optimization of products, processes and practises fitted well with environmental and economic sustainability initiatives and led to the development of several resource management studies that aimed to increase productivity using fewer resources (do more with less). Despite these efforts, global consumptions continue to grow, while resources keep depleting (European Academies' Science Advisory Council, 2016).

An industrial sector that is potentially vulnerable to this challenge to becoming more sustainable is the toy industry. As a largely non-essential product, when compared to food, shelter, and clothing, toy purchases rise as the disposable income of families increase. Furthermore, over the past 20 years, toys have become more sophisticated and required more materials. The falling cost of electronics has seen this technology increasingly incorporated into toys, therefore whilst the dolls may not be bigger, it now speaks, dances and sings. Toys have moved from wood and stones, to pressed tinker toys, to a plethora of polymers, printed circuit boards, and all sorts of materials and requires a constant source of power to maintain its functions (Muñoz et al., 2008). Figure 1-1 shows the diversity of materials different type of toys. Not only are the impacts of a modern toy worsening than its early wooden handmade and locally sourced origins, the number of toys purchased per child has increased at a concerning rate.

The assertion made in this thesis is that our current trend of resource consumption is unsustainable, and that market economics alone will not guarantee a stable, secure, and equitable society. In its current form, our financially based global economic system cannot deliver a fair, equitable and sustainable future. It is only reasonable to assume that demand for valuable and scarce resources will continue exceed supply. Alternative methods of allocating resources, such as rationing by product/sector importance will be required. In this scenario, to access these limited resources, companies will not only have to demonstrate their environmental and lean manufacturing potential, but also the positive values that their products bring to society. The aim of this research is to embed positive societal benefit consideration into sustainable toy manufacturing business strategic decision making.

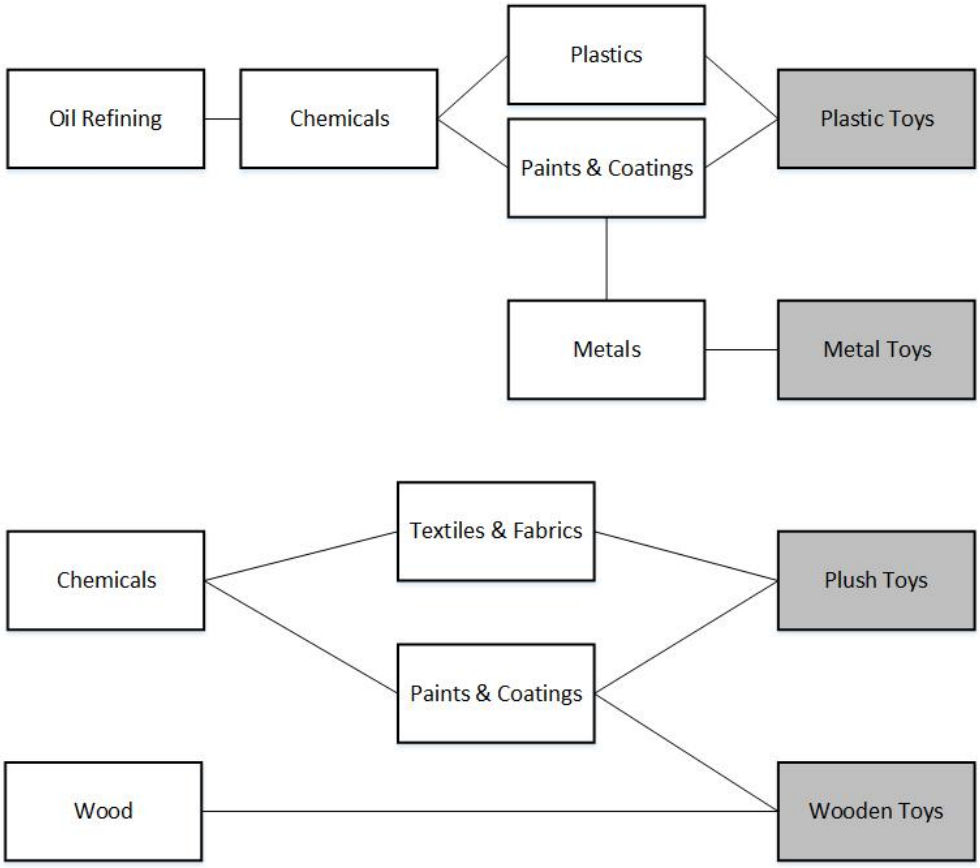

Figure 1-1 Materials flow of different types of toys

The research for this thesis is structure in three distinct sections: research background and overview, theoretical research and method development, and research conclusions as shown in Figure 1-2. The first section, Research Background and Overview, provides an introduction to the research, exploring the issues surrounding sustainable product design, social impact assessment, and the toy industry. There are five chapters included within this section; Chapter 1 introduces the subject and provides an over view of the thesis structure, Chapter 2 provides the context for the research explaining the aims and objectives together with a description of the research scope, Chapter 3, 4, and 5 are review chapters. Chapter 3 reviews the relevant background to the research, which includes overview of sustainability, the product design strategies for resource management, and the toy industry. Chapter 4 reviews the most common sustainable design methods, tools, and techniques applied, and examples of these tools in the toy industry. Chapter 5 reviews recent research in the social considerations of sustainable product design, the social life cycle assessment methods, and the benefits of toys.

The second section, Theoretical Research and Method Development, consists of five chapters. As well as the development of a general research methodology, a framework for societal benefit assessment is proposed. The specific requirements for the proposed assessment method are based on the findings of reviews of life cycle assessment and play researches. A toolkit is also developed for the integration of the societal benefit assessment into a strategic support tool along with other assessments. the validity of the overall approach is then tested using case study examples. Chapter 6 outlines the research methodology used in this thesis. Chapter 7 provides a framework for societal benefit assessment. Chapter 8 presents the methods for carrying out societal benefit assessment. The data required, methods of calculation, and interpretation of results are proposed. Chapter 9 introduces a toolkit for integrating societal benefit assessment into a bigger sustainable strategic management picture. Chapter 10 concludes with two case studies to demonstrate the effectiveness of the proposed societal benefit assessment methods and the strategic support toolkit.

The final two chapters of the thesis include the research conclusions and recommendations for further work. Chapter 11 critique of the research carried out for this thesis considering the research contributions made and concluding discussions. Chapter 11 concludes the thesis by identifying the key research conclusions and suggesting further work for the continuation of this research.

Lastly, appendices 1,2, and 3 provides relevant published papers by the author on various aspects of the research reported in this thesis. Whilst appendices 4 and 5 additional information used in chapter 8 and 10 respectively.

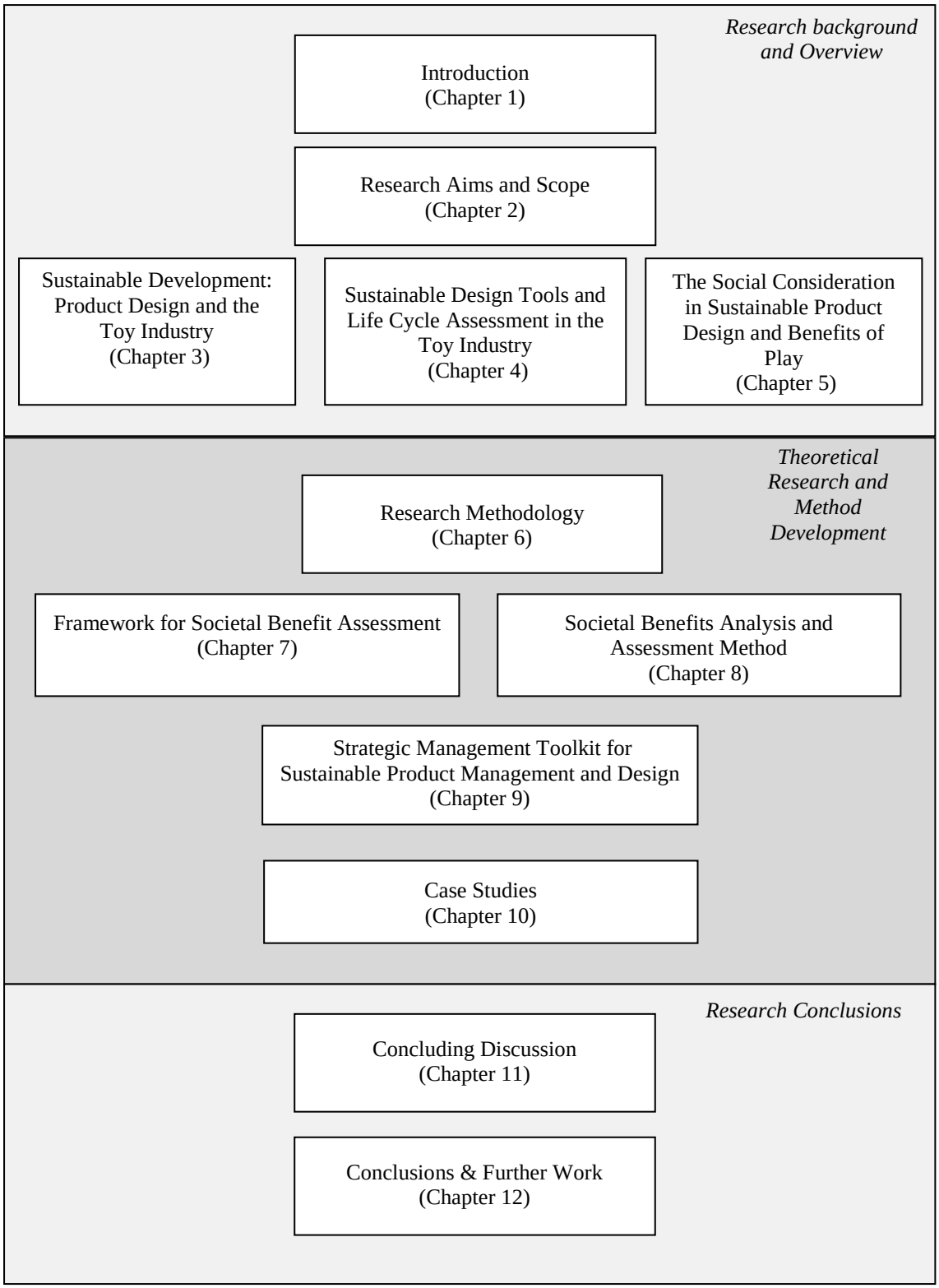

Figure 1-2 Thesis Structure

Chapter 2 Research Aims and Scope

2.1 Introduction

This chapter discusses the research context, overall aims, objectives, and research scope. The preliminary part of the chapter describes the research context and in particular the primary question considered in this research. The later part of the chapter highlights the research objectives and the scope in the context of this thesis.

2.2 Research Justification

The availability of resources has been critical to the development of our modern society and concerns regarding restrictions in supply of various resources, including water, energy, fossil fuels, rare earths, fertilisers and food, have been constantly debated over the years. These concerns have continued to escalate as the increasing demand for diminishing resources have led to political, economic and social unrest. One response to resource scarcity at the national level has been rationing, which has been applied to food, fuels, medicines and benefits. However, at a global level, market forces, technology and military strength and/or political affiliation often determine which countries get greater access to the resources available. This usually results in those people which have consumed the least, suffering the most when shortages occur – a major unfairness!

Resource efficiency is fundamental to Sustainability with the ability to impact positively on all three areas – Environment, Social and Economic (ESE). This has become increasingly important at a consumer, corporate and government level, resulting in consumer pressure groups, corporate initiatives and legislation to affect change across a broad range of industries, notably consumer goods, agriculture, automotive and energy generation. The toy industry is no exception to this with Corporate Social Responsibility reporting (CSR) and ISO14001 standards being adopted as part of a concerted effort to move towards ESE sustainability. However, many of the methods and tools used to achieve this (LCA, Footprinting, DfE) focus on reducing the negative ESE impacts of the product on a functional unit basis with obvious limitations. In a future resource constrained world, incremental

improvements and best practise will not be enough, tough decisions will need to be made as to which human needs or wants will be met, rather than which product will be chosen to meet those needs. The ability to assess products based on the contribution to society (Social Value) will be as important as assessing the products sustainability footprint.

To some degree the Toy industry is ahead of other industries in this regard, (e.g. automotive, white goods, food) as some toys are marketed on their 'play value' rather than desirability alone. These 'play values' can include factors such as educational, communication, fitness and motor skills. The value of toys to children has been recognised since early civilisation with archaeological records and remains of dolls. being recorded. Through play the world is explored and basic motor skills are developed and toys are one of the main 'tools' for this purpose. As with other sectors, the toy industry has grown dramatically since the industrial revolution and the growth in net wealth and disposable incomes. Nowadays, toys are mostly mass manufactured and come in many different forms, these variations create a number of categories of toys and encourage different innovative ways of play. However, the toy market is very crowded and the increased competition and pressure to increase sales has led to over consumption and a throw away culture. Furthermore, little consideration has been given to the end-of-life management of toys, where discarded products most likely end up in landfills or incinerators.

Current efforts in improving sustainability in the toy industry have been focused in material reduction and substitutions, reduction in packaging and improving working conditions within manufacturing facilities. These are all valuable activities and should be encouraged to continue, however they may not be the solution to stop or reduce global resources depletion. It was reported that an average child in the UK receives 44 new toys a year (London, 2012) and owns 238 toys while only plays with 12 of them most of the time, that is 5% of the total. (O'Grady, 2010) These facts suggests that toy supply is actually exceeding demand and resources are being needlessly and inefficiently consumed.

2.3 Research Assertion

It is asserted in this research that our current rate of resource consumption is not sustainable, therefore manufacturing businesses will not only need to establish their financial capability and environmental credentials, but more importantly to demonstrate their products social benefits in order to access scarce and valuable resources.

2.4 Research Questions

In order to better understand how the social value of products are being measured, such that different products can be compared for future resource allocation decisions. This research will address the following key questions:

1. To what extent are social values considered in manufacturing businesses?
2. Within the toy industry, how are sustainable considerations integrated in the product design process and wider business management activities in particular regarding the social dimension?
3. What are the considerations, metrics, and method required to provide an objective, quantitative assessment to compare products with dissimilar functions?
4. How can knowledge gained from such assessment support decision making at product design and business management levels?

2.5 Research Aim

The aim of the research described in this thesis is to explore the opportunities and challenges for embedding positive social factors into strategic decision making of toy design and manufacturing companies. This is achieved thorough:

1. Development of a novel framework and method for assessing the positive social factors of products.
2. Development of a toolkit that integrate the framework with other sustainable assessment to support business planning and product design practices.

2.6 Research Objectives

In order to achieve this aim, the following objectives have been identified:

1. To review current status of sustainable development in the toy industry, to identify methods and design tools for evaluating sustainable impacts of toys, and to investigate the economic, environmental, and social impacts of toys.
2. To formulate a systematic framework to assess the positive social impacts of products to their users and their wider society.
3. To develop an assessment methodology to identify and quantify positive societal benefit of products.

4. To develop a decision support toolkit for toy companies and to incorporate social factors considerations into business strategic management.
5. To demonstrate the applicability of the assessment method and the decision support toolkit through case studies.

2.7 Research Scope

The objectives of this project have been used to define the projects scope as follows:

1. *To review current status of sustainable development in the toy industry, to identify methods and design tools for evaluating sustainable impacts of toys, and to investigate the social impacts assessment of toys.*

This section features literature reviews of three main area of research: sustainable development in the toy industry, methods and design tools for evaluating sustainable impacts of toys, and the economic, environmental, and social impacts of toys. The first area of review is the current structure, business practices, and sustainable efforts of toy industry are reviewed. It will explore the current toy products, typical materials, manufacturing processes, and toy classification methods. These reviews will provide the knowledge to direct the initial focus of the research.

The second area of review is to identify methods and design tools for evaluating sustainable impacts of toys. This section of the review will look at current product design process. Sustainable design tools were reviewed to comprehend existing tools that provide assessment and improvement recommendations for products' sustainability.

The last area of review is to investigate the social impacts assessment of toys. this section of review investigates the notion of social consideration in sustainable design, and current available assessment method that considers social factors. The play value of toys is also investigated for better identification of social benefits of toys and a potential assessment for such values of toys.

2. *To formulate a systematic framework to assess the positive social impacts of products to their users and their wider society.*

This includes the establishment of a framework that provides a step-wise approach to assessing the positive social impacts of a product, and allowing the comparison of products with distinct functions to be made based on the benefits to society. This framework will provide a structure

to assess the products' functionality, to identify the relationship between functions and the positive impacts, and to quantify these impacts.

3. *To develop an assessment methodology to identify and quantify positive societal benefit of products.*

This section includes the establishment of a methodology to assess products' sustainability specifically its social benefits. Parameters for measurement will be determined from previous reviews.

4. *To develop a decision support toolkit for toy companies and to incorporate social factors considerations into business strategic management.*

This includes the establishment of a toolkit that compiles sustainable assessment methods and techniques to effectively apply data for evaluation of toys. The tool will also provide a holistic approach to visualise sustainability of toys and provide strategic, technical, and design recommendations for improvements. This tool kit will ensure clear translation and communication of strategies into actionable design requirements. This in turn helps compare and improve sustainable performances of their toys

5. *To demonstrate the applicability of the assessment method and the decision support toolkit through case studies.*

Suitable case study products and/or companies will be selected to demonstrate the effectiveness of the decision support toolkit and assessment methods in a commercial application. Firstly, the proposed assessment method will be used to determine the positive social impacts of selected toys from two companies and their competitors. Secondly, the tool is applied along with environmental and economic assessment results to determine actions and subsequent design improvements and suggestions for toys.

Chapter 3 Sustainable Development Product Design and the Toy Industry

3.1 Introduction

This chapter begins with an outline of sustainable development, its background, advancement, and future concerns, particularly resource depletion. This will be followed by an overview of product design practise and theories, design for sustainable development and design strategies for sustainable resource management. The final part of this chapter will discuss the toy industry, its market and practices, categorisation methods, materials used in various categories of toys, and toy safety regulations.

3.2 Sustainable Development

Awareness of sustainability has been slowly driven by environmental concern over the last few decades. However, it has taken great strides in recent decades as scientific studies and the economic effects of ecological impacts have drawn attention to the challenges lie ahead. This has, in turn, shifted the governments and general public's focus from preserving to securing a better future.

It was environmental issues that were first brought to the public's consciousness by Carson 1962 release of "Silent Spring". This initiated a shockwave of greenwashing and had driven governments to change their policies. This was followed by an increasing in researches that aimed to better understand the ecological factors and effects. In 1987, the UN Environment Commission Report set the tone for sustainability efforts to follow. More commonly known as the Bruntland report, it defined sustainable development as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (World Commission on Environment and Development, 1987). This definition put in place a clear three-fold conceptual framework for sustainable develop: economic growth, social inclusion and environmental protection.

A key moment for SD was the United Nations Conference on Environment and Development, more commonly known as the “Earth Summit”, held in Rio de Janeiro in 1992. UN member states agreed to launch a process to develop a set of goals for pursuing focused and coherent action on sustainable development (Le Blanc et al., 2012; United Nations, 2012). The Rio Declaration on Environment and Development is seen as the cornerstone of SD, a set of 27 principles were promoted. Concepts includes centrality of human beings to the concerns of sustainable development (Principle 1); the primacy of poverty eradication (Principle 5); the importance of the environment for current and future generations and its equal footing with development (Principles 3 and 4); the special consideration given to developing countries (Principle 6); the principle of common but differentiated responsibilities (Principle 7). It also presented the two critical economic principles of polluter pays (Principle 16) and the precautionary principle (Principle 15). It introduced principles relating to participation and the importance of specific groups for sustainable development (Principles 10, 20, 21, 22) (Le Blanc et al., 2012).

At present, the environmental effects are clearly visible and there is constant news coverage of climate change, biodiversity preservation battles and air pollution. However, there is little or no concern for the economic factors which are changing manufacturing companies’ practices and in turn affecting society. For example, the rises in energy cost, and resource and material deficiency which are triggering supply fluxes and rocketing prices. These factors have pushed governments and industries to react with works in efficient use of energy and resources, developing alternative materials and solutions where costs are unaffordable.

It is predicted that these factors will increase the pressure both economically and socially. Many governmental and corporate organisations have carried out forecasts and assessments to comprehend world changes in the near future (DTI, 2002; European Commission, 2012; OECD, 2012a; UNEP, 2012; WBCSD, 2010). Future trends that will directly impact product development and manufacturing are identified and summarised from a series of studies and reports

- Global consumption will continue to rise, driven by a growth in global population coupled with emerging markets and improving living standards in developing countries, and an ageing population in developed countries.

- Significant effects brought to societies by the changing social factors, a changing climate, growing urbanisation and challenges with food production and developing infrastructures to support an improving quality of life.
- Resource depletion, energy security and water scarcity will continue to cause supply and cost problems.

From these, it is obvious that the world is going to change. While it is unclear how it is going to change, it is noticeable that the world is on the verge of substantial changes environmentally, socially, and economically.

3.2.1 Sustainable Development Goals

These changes are partly caused by the implementation of UN Sustainable Development Goals (SDG). One of the main reasons for SDG is our crowded planet. It was estimated that there are currently 7.6 billion people on planet earth. The world population is predicted to continue rising by about 83 million people per year, and a total of 9.8 billion people by 2050 (United Nations, 2017). These billions of people will need their foothold in the world economy. The world economy is vast and highly unequal in the distribution of income within countries and even between countries. Whilst billions of people are enjoying longevity and good health in the developed countries, at least a billion people live in poverty that they struggle for daily necessities to live (The World Bank, 2018).

Furthermore, the world economy is not only unequal but also threatening to earth's ecosystem. The large scale of the world economy is creating an environmental crisis, which threatens the lives and well-being of the population and the survival of millions of other species on the planet. It is for this reason that the UN presented and promoted SDG.

The SDG is a set of targets to end poverty, ensure that all people enjoy peace and prosperity and, protect the planet. These three main aims correspond to the three pillars of the conceptual SD framework. A total of 17 Goals were set based on the successful Millennium Development Goals, while new areas such as climate change, economic inequality, innovation, sustainable consumption were added. The SDG provides clear guidelines and targets for all countries to adopt in accordance with their own priorities and the environmental challenges of the world. It aims to tackle the root causes of poverty and unite us together to make a positive change for both people and planet. It is important to note that SDG encompasses the ideal of SD and its three-pillar approach.

As Salamat (2016) pointed out, the key to achieving SDG is to ensure the integration of environmental protection and social development with economic growth, which remains the primary objectives of most governments. Therefore, it is of vital importance to decouple global economic gains at the expense of environmental degradation and social inequality. Of the 17 goals in SDG, Goal 12 is the most relevant to this research, it aims to ensure sustainable consumption and production patterns. It entails frameworks and tools to support efficient use of resources. This goal is an effort to tackle global resource depletion.

3.2.1.1 Resource Depletion and Conservation

Resource conservation and efficiency is an integral part of sustainable development. It refers to the management of renewable and non-renewable resources. Renewable resources include water, soil, and other natural resources, these resources can replenish over time; non-renewable resources such as fossil fuels and critical materials cannot be replaced, and the availability of these key resources presents huge sustainability risk (Coulomb et al., 2015; European Academies' Science Advisory Council, 2016; OECD, 2016). Figure 3-1 shows the availability of key material resources, and the year that it would be used up, in three scenarios: business as usual, 50% recycling, and 75% recycling realisation. It shows how critical some of the know reserves are and the importance of an effective global resource efficiency management strategy (European Academies' Science Advisory Council, 2016).

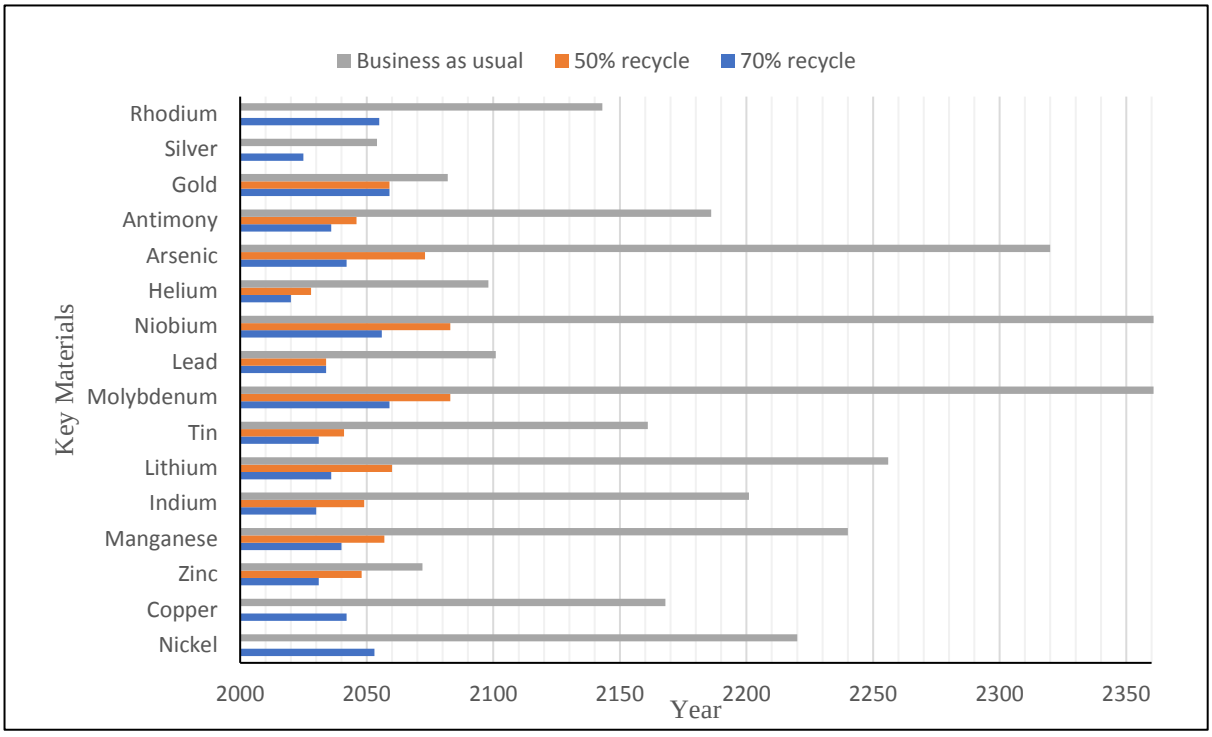

Figure 3-1 Expected lifetime of materials supply in three scenarios

3.2.2 European Commission Sustainable Legislations and Policies

Europe has been at the forefront in driving sustainable development. A number of policies and legislations has been put in place to realise SDG and secure a sustainable Europe. These includes Integrated Product Policy, sustainable Consumption and Production and Sustainable Industrial Policy Action Plan, and Roadmap to Resource Efficient Europe 2011.

3.2.2.1 Integrated Product Policy

The European commission has a number of legislations and action plans to improve resource efficiency and reduce environmental impacts. One of the first legislations is the Integrated Product Policy (IPP). Consultation study was carried out and published by Ernst & Young and the university of Sussex in 1998 (Ernst & Young, 1998). A subsequent Green Paper was published in 2001, the paper proposed a strategy to redirect and strengthen product orientated environmental policy. IPP is defined as a "public policy which explicitly aims to modify and improve the environmental performance of product systems." (European Union, 2001), it aims to provide a variety of tools – both voluntary and mandatory – to reduce environmental impacts of products through their manufacturing, use, or disposal. It has three main focuses; products, environment, and the life cycle of the product. Five key "building blocks" are also proposed:

- Reduction and management of wastes generated by the consumption of products.
- Innovation of more environmentally-sound products, this is achieved through research and development of technologies and products, and measures to encourage the environmental management of products.
- Creations of market for more environmentally-sound products in both the private and public sectors.
- Transmission of information along the product chain, this is achieved by encouraging greater transparency about the environmental burdens and full environmental costs of product systems. This information will serve to change customer behaviours.
- Allocation of responsibility for managing the environmental burdens of product system. This aim to allocate legal and financial liability for the product-system environmental burdens. (European Union, 2001)

IPP has provided a foundation for environmental legislations and actions for sustainable development in Europe.

3.2.2.2 Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan

As a continuation of the IPP, the European Commission has published the Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan (SCP/SIP). It comprises of a number of proposals on sustainable consumption and production that will positively influence the environmental performance of products and increase the demand for more sustainable goods and production technologies.

There are four core actions in SCP/SIP: setting benchmark performance for products, introduction of eco-labelling, public procurement and incentives, and smarter consumption guidelines. These four actions are translated into a number of policies and schemes that have been implemented in Europe since the presentation of the SIP/SCP action plan in 2008. These includes Green Public Procurement (GPP), EU Ecolabel, Eco-Management and Audit Scheme (EMAS), Eco-design Directive, Environmental Footprint Methodology etc. GPP is a voluntary policy which supports public authorities in purchasing products, services and works with a reduced environmental impact. EU Ecolabel scheme sets requirements and standards for products' environmental performance and inform customers for better shopping choice. It was reports that the EU Ecolabel increased its number of licences for the top environmentally performing products from 1357 in 2011 to 1670 in 2012, an increase of almost 25 % (European Commission, 2013). EMAS is a voluntary environmental management instrument, which was developed in 1993 by the European Commission. It enables organizations to assess, manage and continuously improve their environmental performance. It is similar to ISO 14000 group, it uses energy efficiency, material efficiency, water, waste, biodiversity, and emissions as indicators to drive continuous improvements in Eco-management. The Eco-design directive provides an EU-wide framework for setting requirements on energy related products to improve their environmental performance at the design stage. It was estimated that the first 12 Ecodesign Regulations will allow savings of 385 TWh per year by 2020 (European Commission, 2013). Environmental Footprint Methodology aims to set a set of unify indicators for reporting on organisations' general environmental performance.

3.2.2.3 Roadmap to Resource Efficient Europe 2011

In 2011, the European Commission published the Roadmap to Resource efficient Europe, it set sustainable milestone for 2020 and final targets for 2050. It focuses in four key areas, energy, food, buildings, and environmental burdens. These are assessed in nine key impact categories:

fossil fuels, material and minerals consumption, water, air, land use, soil degradation, biodiversity, marine resources, and waste.

Although, significant improvements were brought about due to increasing awareness of our sustainable impacts, it has become increasingly apparent that these efforts are not enough and radical changes are required in order to meet the targets as illustrated in Figure 3-2 (DECC, 2012; UNEP, 2011a, 2012). This is echoed by Stern (2007), who further pointed out that in order to mitigate the effects of our current impacts, 80% reduction of present damages is required. Therefore, it is widely accepted that meeting such difficult targets in the near future will require a strategic, integrated, and radical approach, and a momentous change to current production and consumption system.

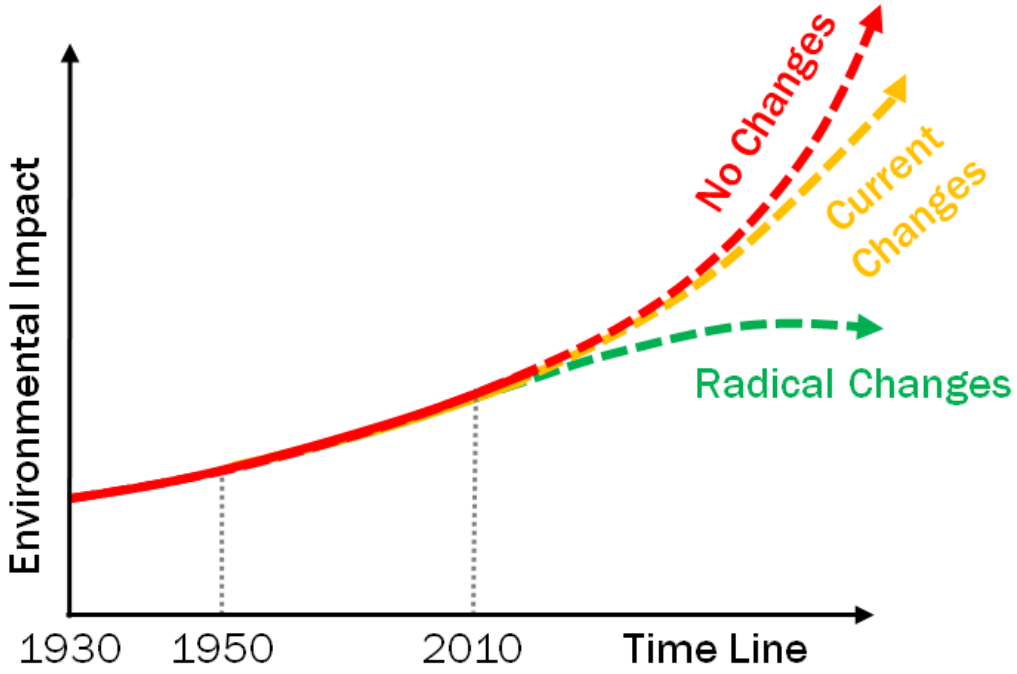

Figure 3-2 The environmental impacts gap

3.2.2.4 Impact of the 2008 economic crisis on sustainable development

The 2008 economic crisis came at a critical point regarding public awareness and promotion of resource efficacy and other sustainability related issues. Early prediction was not optimistic, a common viewpoint was that governments would focus on nurturing the fragile economy by not burdening businesses and industries with extra costs and regulations, in order to preserves jobs (Wooders and Runnalls, 2008). This speculation was based on the fact that progress on sustainable policies was slow even before the crisis, despite high economic growth. It was observed that sustainability transitions were only entering their take off phase the decade before the crisis (Oosterveer and Spaargaren, 2012). Indeed, public ‘s attention mainly focused in rebuilding the economy as illustrated in Figure 3-3 and 3-4. The figures show the percentage of a sample of 1000 British adults who rank “environment” and “economy” as one of the most important issues (Geels, 2013). They clearly show a decline for environmental issues since 2009 and a sharp increase in prioritising economic rebuild. Geels (2013) suggested that while initial impact of the economic crisis on sustainable development was perceived as negative due to drop in public attention and lack of finance to drives sustainability related investments, the outlook was positive due to three factors:

1. The underlying problem for sustainable development will always be a persistent issue.
2. Growing confidence and potential governments policies will encourage sustainability related investments, as previous lack of investments was due to lack of confidence rather than lack of cash (Zenghelis, 2012).
3. Public attention will increase due to new scientific findings, natural shock events, or enhanced activity from social movements (Geels, 2013).

In summary, the effects of the economic crisis on sustainable development may have knocked back the application and transition of research during the few years after the crisis. However, researches have persisted, and it was observed that financial investments, a key driver for sustainable research and application, have since increased steadily (McCrone et al., 2011)(Figure 3-5)

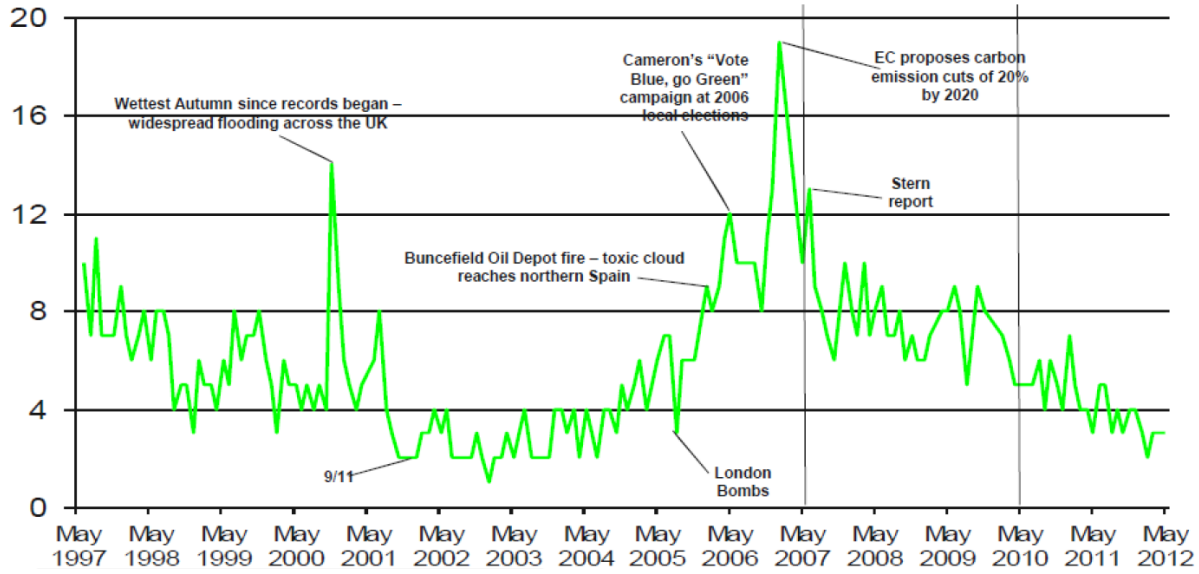

Figure 3-3 Percentage of a sample of 1000 adults who rank 'environment/pollution' as one of the most important issues facing Britain (Geels, 2013)

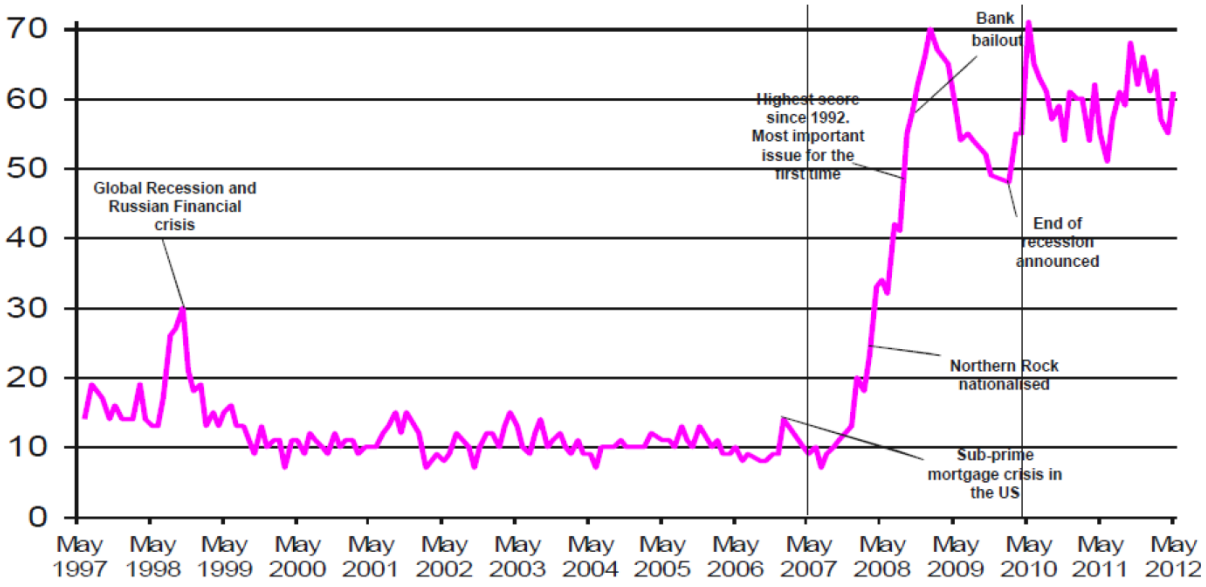

Figure 3-4 Percentage of a sample of 1000 adults who rank 'the economy' as one of the most important issues facing Britain (Geels, 2013)

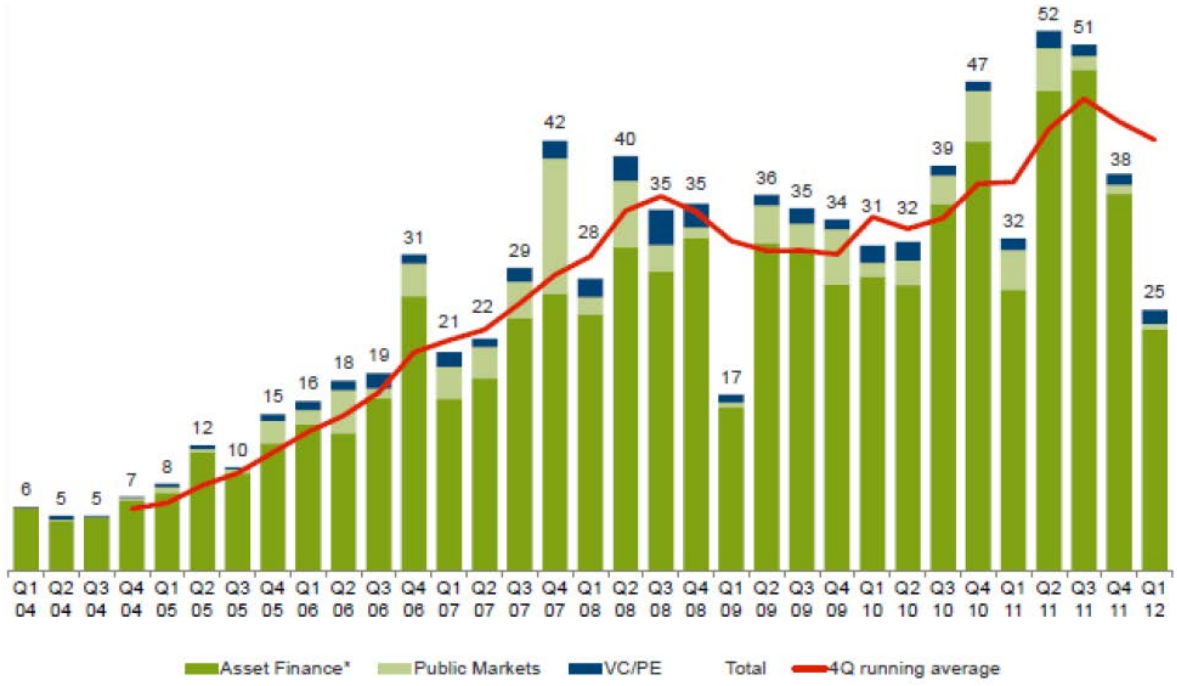

Figure 3-5 Quarterly trend in renewable energy investments $billion (McCrone et al., 2011)

3.2.3 Resource Depletion

It is estimated that 3.1 planets worth of resources are required to support our current resource consumption (Figure 3-6). Global population has been growing. The reliance on finite resources to meet its needs and wants may eventually consume all accessible resources, which may result in a collapse of our current global civilisation (Rahimifard et al., 2013; Turner, 2008). Consumption of finite resources is one of the critical aspects that contribute to sustainable impacts of manufacturing industries. Efficient distribution and consumption is key to addressing sustainability impacts. Although resource efficiency has been traditionally driven by economic mean, in maximising financial profits through efficiency in labour, materials and energy consumption, whilst reducing waste. The same approaches have been transferred to embrace sustainable strategies where there is a greater emphasis in conservation of resources and balancing consumption of materials, water, and energy with financial profits and loss account (Dahmus and Gutowski, 2005).

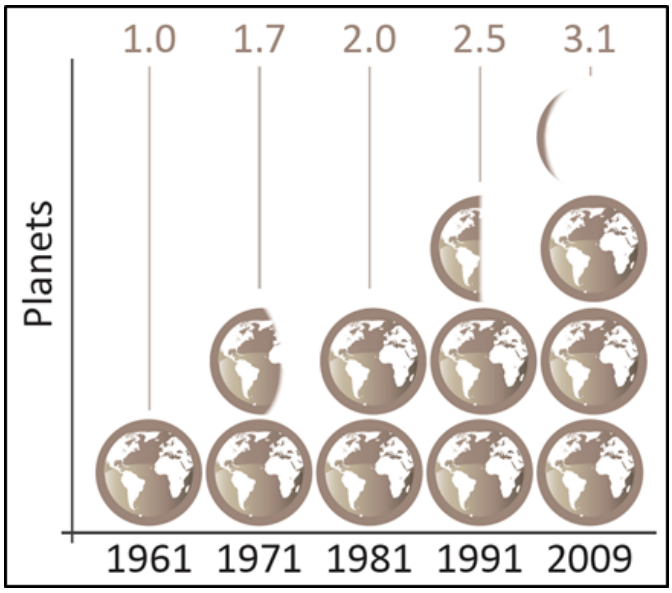

Figure 3-6 Amount of resource required to support UK's level of consumption

3.3 Product Design

Creativity is one of many innate skills that humans possess. Designers and engineers come up with creative solution for particular problems on a daily basis. Problem solving involves creative thinking with effective logical presentation. Traditionally, designers were regarded exclusively as stylists, however today's designer also has a working knowledge of technology, manufacturing processes, anthropology, marketing, and finance (BTHA, 2009). Modern designing process organises and manages design projects efficiently and to aid the effective communication of creative and innovative ideas. It is a multi-disciplinary approach which requires effective communication within the business, and to clients and consumers.

The product design process normally consists of a series of sequential, iterative phases that ensure logic and record of the generation and development of ideas. The phases are followed to ensure ideas can be traced and market/ customer needs are fulfilled. These phases are grouped into clear stages, where critical decisions are made at each phase. There are several existing product design models, one of the more established example would be Stewart Pugh's 6-stage product design framework (Pugh, 1991). The 6 stages are Marketing, Specification, Concept Design, Detail Design, Manufacturing and Sell. All stages feed off the preceding stage in that order and follow clear logical progression with traditional design principles applied to each stage. Specific tasks have to be completed in order to progress to the next stage (Table 3-

1). Ulrich & Eppinger (2000) devised a similar model for the product development. A list of processes is also described. These processes can be customised to fit different companies' practise and requirements, although these activities varies in detail, the core stages are often the same in many applications, and even across different fields (Howard et al., 2008).

Various focuses have been developed and integrated into the design process over time. Instead of solely satisfying a customer need and manufacturing as many products as possible at a minimal cost, the scope of the product design process has expanded to a wide range of design aspects. These aspects includes quality engineering (Taguchi, 1986), design for assembly (Boothroyd, 1982; Boothroyd et al., 1994) design for disassembly (Boothroyd and Alting, 1992), design for recycling (Henstock, 1988), and many more aspects in design process.

Table 3-1Product design process and tasks

Design Stage	Tasks
Marketing	▪ Market analysis ▪ Identify market gap ▪ Identify customer needs
Specification	▪ Product requirement detailed ▪ Size ▪ Function ▪ Durability ▪ End of Life considerations, etc.
Concept Design	▪ Initial ideas generation ▪ Ideas comparison and evaluation ▪ Selection of idea
Detail Design	▪ Development of selected idea ▪ Full design validation
Manufacturing	▪ Production of products
Sell	▪ Sales ▪ Market and customers feedback for redevelopment.

One of the more significant development of these is Design for Sustainability (DfS), aslo referred as Sustainable Design (SD).

3.3.1 Drivers for SD

There are three major drivers for SD: Ecological, Government and Political, and Consumer drivers. As described earlier in the chapter, environmental impacts and effects are more apparent. The increase in the knowledge of environmental impacts and their causes is surely going to influence product design activities and design decisions. As the environment challenges are more evident, global governmental organisations have devised several ways to combine environmental concerns into legislations and policies.

Key progress milestones such as the Rio Earth Summit, agreements at the Kyoto Protocol, and more recently the Paris Agreement have filtered down into a wide ranging and large number of policies that are implemented by governments globally (United Nations, 1992, 1998, 2015). The policies have directly influenced and regulated corporate business behaviours. These policies directly affected product development and incorporated environmental considerations in line with regulatory requirement.

Consumers have increasing influence in SD, as they have more demand for sustainable and environmentally friendly products. It was found that there is a positive correlation between increased eco-activities and sales (Oehme and Kemp, 2012). Other studies further pointed out that customers are well intentioned and would prefer environmentally products (Chen et al., 2012; Ginsberg and Bloom, 2004). However, this has not translated to actual sales in practice, due to complicated trade-offs and perceptions of quality and performance (Young et al., 2010). This indicates that customers demand high quality performance as well as the increasing environmental demands.

Consumers are increasingly aware of a number of labelling, standards, and certifications that encourage voluntary adhesion to performance standards of manufacturing activities, product safety and performance. Industry standards are created by governing standards bodies, it is intended to promote best practices. Standards typically provides supporting information for companies and businesses to improve practices. Examples can be the ISO 9000 groups for quality management, ISO 14000 group for environment management, life cycle thinking and implementations etc (ISO, 2005, 2006a, 2006b). Labelling and product certification works in a similar way, however, the information provided is more specific to the

products which are required to conform to clearly defined specifications for the certificate or label. An example of these is the “lion mark” for toy safety which ensure conformance to the Toy Safety Directive in the UK. Consumers are going to be a major driver for SD, as many companies expect their future business success to be dependent upon engaging with consumers and sustainable activities (Lacy et al., 2010; Sheth et al., 2011).

3.3.2 Resource Management Strategy in SD

In sustainable thinking, resource efficiency can be focused in material, water and energy. One of the problems with classifying materials as a separate resource is that material availability can be intrinsically linked with the other resources such as energy and water. Material efficiency is defined as the provision of a product or service with less material production (Allwood et al., 2010). This has a clear emphasis in materials where reduction or change in material may result in reduction in environmental impacts.

There are two material efficiency strategies in general: design changes and process changes (Figure 3-7). Design changes involve the changes in what is being manufactured, while process changes only change the manufacturing operations, though changes in design may also require process redesign.

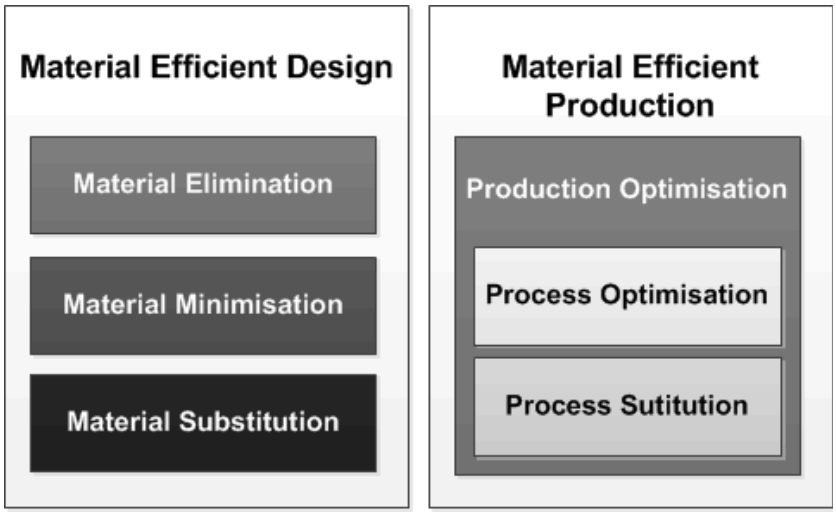

Figure 3-7 Material efficiency strategies

3.3.2.1 Material substitution

Stronger, stiffer, or tougher materials are substituted into a product to meet the same functional specification for less material used. Additionally, this offer potential reduction in sustainable impact as more readily recyclable and less impactful materials can be applied (Holloway, 1998). In the past, this strategy has mainly been driven by the aim to lower toxicity of a product, such as the substitution of lead in paint, solder and petrol. CES is developed for reducing the embodied energy of materials within product while maintaining same properties (Figure 3-8). However, some materials that have a low embodied energy and similar properties may be more difficult to machine, such as stones as a possibility to replacing cement, where cement is a lot easier to work with.

Composite materials also present great potential for replacement of aluminium for its superior stiffness and light weight; however, composites materials are currently non-recyclable, which is a negative factor for the possibility of close loop manufacturing and material flow. Renewable biopolymers are also a possibility, as it shifts away from reliance on fossil fuel (Colwill et al., 2012; Ibáñez García et al., 2010). However, future scenarios have been examined and it is unlikely that the capacity for generating biopolymers will be sufficient to meet demand, due to conflicting and constricted land use (Colwill et al., 2012)

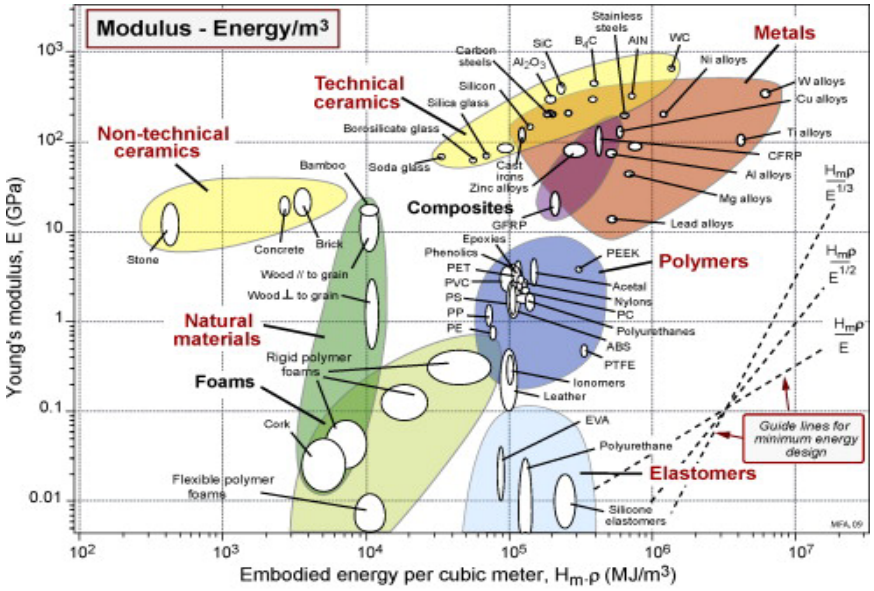

Figure 3-8 Materials selection options through comparing stiffness and embodied energy, from Ashby (Ashby 2009)

However, integrating sustainability considerations into material selection is a more difficult task that is not routinely carried out (Szekeres and Jeswiet, 2013). Material substitution and selection itself is even without the integration of sustainability considerations (Jahan and Edwards, 2013). Various methods have been successfully utilised to enable an easier selection decision; such as, Quantitative analysis methods (Farag, 2008), cluster analysis methods (Johnson et al., 2002), and multi-criteria decision making methodologies (Çalışkan et al., 2013; Sirisalee et al., 2004). However, incorporating sustainability factors into material selection presents a greater challenge, although guidelines have been developed (Ljungberg, 2007; Simões et al., 2013).

3.3.2.2 Material minimisation

Material minimisation is more commonly known as light-weighting, which involves reducing the required amount of materials for the same function (Allwood et al., 2013). This is typically enabled by a finite element analysis (FEA) to design components that meet performance requirements whilst utilising the least amount of materials. Recent case studies in minimising metallic materials in products through light-weighting have been studied (Carruth et al., 2011). It is learnt that 25-30% of required steel and aluminium in product can be reduced. However, there is a tendency in design towards an overcompensating safety factors to avoid component failure, this practice becomes a major barrier for implementation of material minimisation.

3.3.2.3 Material elimination

Material elimination is the complete exclusion of a certain material type from the products. This involves examining the design of the products and looking for opportunities to reduce the total number of material types by removing all unnecessary materials. This can potentially be material substitution, where a material type is completely replaced with another material that is already contained in the product. Therefore, elimination's aim is to reduce the total number of material types regardless of the total amount of materials change. Materials elimination offers the dismissal non-value adding materials and process and better possibility for recycling. An example of material elimination in manufacturing is the use of in-mould labelling to eliminate the need for a separate label.

3.3.2.4 Dematerialisation

Dematerialisation offers radical improvements in material efficiency (Persson, 1999). It is a complete redesign of the whole product service system for materials distribution. An obvious example is the recent shift from physical music records and CDs to digital music files (Hogg

and Jackson, 2009). However, it has been found that a rebound effect is present where the impact related to physical hardware has cancelled out the initial dematerialisation benefits. Several studies have suggested the necessity for general economy to adapt to dematerialisation (Barrett and Scott, 2012; Steinberger et al., 2010). The potential benefits and design principles of dematerialisation have been described (Persson, 1999). Product service systems (PSS) is another possibility for significant material efficiency where business can be maintained economically (Beuren et al., 2013). Figure 3-9 illustrates the classification of PSS.

However, it has become increasingly evident that these efforts are not enough; radical changes are required in order to achieve the sustainable management and efficient use of natural resources by 2030 which is one of the targets for responsible consumption and production from the Sustainable Development Goals, which followed the precedent set by the Millennium Development Goals (UNEP, 2011b). This can be demonstrated in the Allman definition of material efficiency.

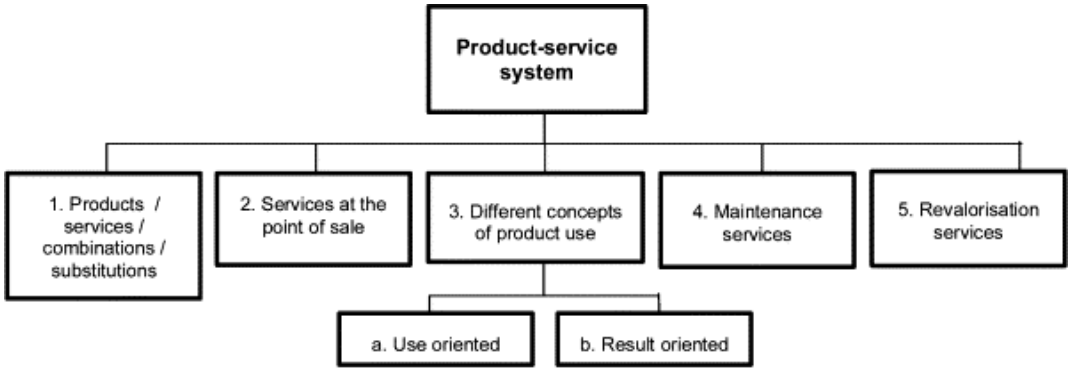

Figure 3-9 Classification of a product–service system. From Mont (Mont 2002)

Considering the Allwood definition of material efficiency as an equation:

$$E_{material} = \frac{P_{product}}{M_{used}}$$

Where

E is Material efficiency

P is Provision of product and service

M is Material used

Thus, decrease in material used or increased in provision of services and products will improve material efficiency. Material efficiency can be achieved by reducing material used, both in design change and material substitution. It can also be achieved by increasing the provision in product and service. Current efforts in improving efficiency have been focusing in quantitative changes as oppose to qualitative changes. However, provision of services and products can also be increased qualitatively where the quality of the products are enriched. The product's societal benefits and determents should be assessed. Benefits should be enhanced and detriments should be removed by product redesign.

By and large industries, such as automotive, white goods and food, do not have the necessity to address this idea of enhancing societal value of their products. This may be because of their products function and customers' needs are clear. For products that have more ambiguous functionality it is hard to assess performance quantitatively let alone increasing that. To some degree the toy industry is ahead of other industries as rather than desirability driven, toys are often marketed on their play value, which is a set value to an ambiguous act (Fundamentally Children, 2017). Play as an action or activity has been discussed in more detail in the seven ambiguities of play (Sutton-Smith, 2009).

3.4 Toy Industry

The global toy market size is estimated to be $83.3 billion in 2010. Europe accounted for 27% of revenues (TIE, 2013),with the United Kingdom, France, Germany, Italy, Spain, Belgium, Austria and Portugal being the second to tenth biggest market in the world (NPD Group 2012). There are currently 5000 toy companies in Europe, about 99% of these are small and medium enterprise (SMEs). Due to competing cost most of the manufacturing takes part abroad, mainly

in China, and all other core primary activities such as research & development (R&D), testing and marketing are completed in Europe (TIE, 2013)

A growing market that is emerging is the electronic toys, especially preschool electronics, such as the Leapfrog tablets for preschool children. The integration of small electronics into toys has been well anticipated. It is regarded as Toy 2.0 and Toy 3.0 (Spielwarenmesse 2013). Toy 2.0 is referred to physical toys that are integrated and used in gaming console, such as the successful cases of Disney Infinity and Skylander. Toy 3.0 is where the play is enabled by the integration of physical toys into hand held "smart" device, such as a phone or tablet.

The toy market itself is highly seasonal, with 50-60% of purchases were made during Christmas period. With such short window of sales, the industry constantly introduces new, innovative and fashionable products into the market to meet the changing desire of children or in other words catching children's short attention span. It is highlighted that the market is getting more and more competitive due to a few challenges that the industry is facing. Firstly, while market has been expanding, the market age range is in fact narrowing due to the fact that children are maturing in a younger age, and toys are getting out-grown a lot quicker. Secondly, the emerging of "tweens", 8 – 10 years old, who are more fashion conscious and demanded more sophisticated toys and entertainment (Wong et al., 2005).

However, there has been growing concern for popular consumerism in the toy industry, thus the question of over consumption of materials. It was reported that an average child in the UK receives 44 new toys a year, and possesses 238 toys and only 5% of them are used most of the time (London, 2012; O'Grady, 2010). Furniss (2013) questions whether that many toys are necessary, and even suggested that the market is in some ways driven by socially-suggested want.

3.4.1 Supply Chain and Market Practice

Toy industry is regarded as one of the oldest creative industries. Creative industries are generally very volatile and seasonal in nature, the toy industry is no exception. Highly variable and unpredictable demands are very short and specific selling windows are the reasons for the volatility and the short life cycle of a product in the market (Wong et al., 2005). The supply chain is identified and described to consist of component/ raw material suppliers, toy manufacturers, toy distributors or wholesalers, toy sellers and toy consumers. Consumers were

identified as parents and grandparents while the decision makers were children. Wong et al. also pointed out that toy components assembly processes are usually very labour intensive due to their complexity, and this is one of the major reason for 8,000 toy suppliers located in China.

3.4.2 Toys Definition and Characteristics

Most people would have toys when they were growing up. However, the definition of toys is not necessarily clear since it seems to be such a trivial matter in our lives. Dictionaries' definitions of toys normally contain five core elements:

1. An object designed to be played with.
2. Something that provides amusement.
3. Something of little value or importance.
4. Non-functional replica of real world items.
5. Normally a diminutive object.

These elements are widely understood to be the elemental characteristics of toys. Element 1 classified that toys are designed and manufactured for play, some other definitions further identified the end-users to be children. This may not be necessarily true, as adults are not restricted from playing with toys either. However, the scope of research is constrained to toys for children aged 14 or under as described in previous chapter Section 2.3 Research Scope. Elements 2, 4 and 5 will be discussed further the later chapters. Element 3 will be studied and further reviews are going to identified and listed the arguable and ambiguous values and importance of toys.

In recent decades, development in materials and other technologies have enabled the expansion in variation and types in toys. Artefacts from earlier civilizations suggested that toys were more than likely to be made from free lying simple materials to hand, they tend to be simple wood or stone crafts (Culff, 1969). As other materials become available, people started to make toys with materials that have other properties. Metal toys become and ceramic toys become more common, there are artefacts from both specific manufactured toys (Bartholomew, 1979) or some one-off handmade items (Chanan and Francis, 1984).

3.4.3 Toy Classification

Nowadays, toys come in many different forms and styles, and there are various ways to categorise the toys into different groups depending on the end purpose. Currently there are no set ways to categorise toys, they can be classified into; 1, Type of Plays or Functions, 2, Target

Age Range, 3, Target Gender, 4, Licencing Brands and Characters, 5, Price Range, 6, Colours, 7, Inherent Skills Development, 8, Regulations and Legislations and 9. Materials and Processes.

Types of play or functions

This tends to be the most common categorising approach. Toy retailers and marketing department in toy manufacturers usually apply this system to their range of toys. Major retailers incline to organise toys into 11 categories with a broader description of subcategories to each category (Table 3-2). This categorising system is more apparent in printed catalogues, normally provided by the major toy retailers or direct purchase catalogues from the likes of Argos and Tesco Direct. Toys can actually cross a few subcategories, in these cases they are put into their primary functional play form. For example, a Furby® is classed as an electronic toy for its interactive play, while in the same time it definitely has enough features to be classified as a doll or even a plush toy.

Target age range

Age is another common method for categorising toys. This methodology also overlaps with Toy Safety Regulation 2009, as there are straighter mechanical requirements for toys intended for children age 3 or under. The market categorising also follows a similar trend. Toys intended for age 3 or above will have less indication of suitability or appropriateness for different age ranges, they are more likely to be reflected on the play form. Toys intended for age 3 or below are more likely to be bigger and more colourful, this is due to the choking precaution requirements and sensory stimulation. This can be seen in the Lego® range, Lego Duplo® is intended for younger children, and they are bigger and will have specific age appropriateness instructions printed on the packaging. Lego Build® is meant for junior, when Lego Technic® and Lego Mindstorm® are more technically challenging and will be more difficult to engage with a younger age.It also worth noticing that toys for 3 years old and younger are usually connected to early development and some may even have a more specific segmented age groups ranging from 1 month old to 36 months (ELC, 2012).

Table 3-2 Toys functional categories and subcategories

CATEGORY	SUBCATEGORY
Action Figure/Accessories & Action Role Play	Action Figure/Play-set/Accessories/ Role Play, Battling Toys & Play-sets
Arts & Crafts	Clay/Dough/Sand, Mechanical/Digital Design, Craft & Paint Kits
Building Sets	Building & Junior Sets
Dolls	Nurturing Dolls & Accessories, Fashion Themed Dolls, Figures & Accessories, Fashion Styling & Dress-up, Play-set Themed Figures & Accessories, Display Doll/Other Doll & Accessories, Doll Houses/Furniture
Games/Puzzles	Games (excl. Trade Card Games), Strat Trade Card Games, Puzzles
Infant/Preschool Toys	Infant Toys, Preschool Toys (excl. Figure), Preschool Figures/Play-sets & Accessories
Youth Electronics	Youth Electronics
Outdoor & Sports Toys	Ride-Ons, Sports Toys, Summer Seasonal Toys
Plush	Plush
Vehicles	Powered Vehicles, Non-Powered Vehicles
All Other Toys	Models & Accessories, All Other/ Miscellaneous Toys, Educational/Musical Toys

Target gender

Due to recent persistent complaints, most major retailers have dropped their gender tags on toy marketing. However, it is still quite clear from a categorising stand point that this sorting method still stands. It is not directly pin pointing gender specific marketing, but action figures and dolls are generally perceived as boys' and girls' toys respectively. This research will not take side on this particular argument, but there will be reviews on toy product design and manufacturing that may concern this specific subject.

Licensing and brand characters

There are various licencing brands, most these licences are generated by popular children television programs. There are also many cases where television cartoons or animations are created because of certain toys, i.e. Hasbro Transformers®. There is also an increasing trend of films and video games licencing, however these are more likely to be made as mementoes and collectables.

Price range and Colours

These two are not main categorising methods, price ranges are more likely to be an add-on option for ease of online shopping and colours sorting are not common at all. In fact sorting toys by their colours is a really strange concept and it can only be found on one discount retailing department store.

Inherent skills development

This particular method is strongly connected with age range. Toys intended for 3 years old and younger will emphasis on the potential skills development from the toys, for example Early Learning Centre's catalogue listed the activities and skills related. Apart from educational and scientific play sets, other toys intended for children 4 years old or above are more likely to focus on the fun and entertainment they can bring rather than skills, as the toys are marketed to the decision maker, the parents, and the end user, the child.

Regulations and legislations

As mentioned in previous paragraphs, toy packaging are legally obliged to bear a sign for toys that are not intended for children under the age of 3. The safety standards EN-71 was drafted using Toy Safety Directive 2009 (TSD 2009) as a foundation. EN-71does not classify the toys, instead it provides a set of safety requirements and testing mechanisms regarding 12 different aspect or features that a toy may have. For research purposes, toys can be divided into different categories relating to the topic being studied. For instance, Pérez-Belis et al. (2013) studied the end-of-life management of small electrical toys and divided the sample of collected toys into electrical and non-electrical toys before further experiments.

Materials and Processes

This method is not so familiar, as Original equipment manufacturer (OEM) and retailers do not or rarely use this sorting method. Contract manufacturers are more likely to use this, as their availability of equipment is the limitation to types of contracts. Toys are not the main driver for materials and new material processes, therefore materials and their corresponding processes naturally divided the subcontractors into groups. This has a weak association with the functioning groups, since there is little innovation in conventional toys manufacturing, i.e. musical toys and construction toys are both injection moulded, and yet they are played and enjoyed very differently in the hands of the child. With that said, due to increase competition there are increasing integration of high degree innovation and superior technological features even in traditional toys and games such as puzzles, board games, dolls and light toys (International Electrotechnical Commission, 2013)

3.4.3.1 Toy classification summary

All in all, there are many approaches in classifying toys and different organisations may deploy a range of methods. The development of online retailing has also enabled a complex network of sorting methodology for better shopping assistance and experience. However, grouping toys to their functional categories is by far the most common primary sorting method. Table 3-3 identified and listed the primary and secondary toy classifying methods by different organisations.

Table 3-3Toy classifying methods deployed by major organisations and research

	Market Researcher	*Conventional Retailer*						*Department Store*				*Supermarket*			*Toy Trade Shows*			*Research*	
Methods	**NPD Group**	**Smyths**	**Hamleys**	**The Entertainer**	**Toymaster**	**MotherCare/ ELC**	**Toys R Us**	**John Lewis**	**Debenhams**	**TkMaxx**	**Argos**	**Tesco**	**Asda**	**Sainsbury's**	**Spielwarenmesse**	**BTHA**	**Hong Kong Toys & Games Fair**	**ECOLEC 2012 (WEEE)**	**Pérez-Belis et al 2013**
Age (Apart from preschool + infants)			S	S	S	S	S	S	S		S	S	S	**P**					
Type/ Function	S	**P**	**P**	**P**	**P**	**P**	S	S	S	S	**P**	S	S	**P**	**P**	**P**	**P**	S	S
Brand/ Characters		S	S	**P**	**P**	S	S	S	S	S	S	S	S	**P**					
Skill						**P**													
Gender (Dropped) (if marked: only for gift suggestion)			S	S		S	S	S	S										
Reg & Leg																		**P**	**P**
Price Range			S	**P**	S	S	S	S	S	S	S	S	S	S					
Colour										S									

P = Primary Method

S = Secondary Method

3.4.4 Toy Materials

Before polymer materials were so widely available and used, toys used to be crafted by hand with some stones or pieces of wood (Chanan and Francis, 1984; Culff, 1969). Subsequently, soft metal became available and machines were developed to press them into more versatile shapes and forms. Nuremburg – Fürth area, Germany, was once the centre of mass produced toys simply because of the advance in the power press and the widely available recycled tin plates (Bartholomew, 1979).

Nowadays, polymers have really taken over as the most commonly used material for toys, this is because of their acceptable cost, mouldability and the capability to produce complex form as the reason behind the rise of the application of plastic in the toy sector since the fifties. most of the toy components and pieces made of polymers have a short life and are thrown away very quickly, as it was hard to reuse these specific components (Ibáñez García et al., 2010). Table 3-4 shows a list of typical materials for toys, their manufacturing processes and application.

Table 3-4 Manufacturing processes in the toy industry (adapted from Ibáñez García et al.2010)

Manu. Processes	Processes	Applications
Injection moulding	HIPS	Solid parts
Blow moulding	HDPE, PVC	Wheels, hollow parts. Figures
Rotational moulding	HDPE, PVC	Hollow parts, containers
Thermoforming	HIPS sheets	Game boards
Calendaring	Plasticized PVC	Thermal sealing of inflatable toys
Fabric Coating	Several polymers	Substitutes of textile material, soft bodied doll
Foaming	PU	Soft play ball
Die-stamping	ABS sheets	Shovel plough
Embossing	PC sheets	3D frames
Metallic	Metallic	Mirror

Toys in present days are not as simple as they once were. Most of the toys will have multiple materials, even the simplest action figures may have several different types of polymers. Coupled this with the advance in the small electronic components manufacturing, many toys have implanted electronics to enhance the products enjoyment (International Electrotechnical Commission, 2013; Muñoz et al., 2008; Pérez-Belis et al., 2013; Solé et al., 2012) Table 3-5 shows a typical composition of a toy with electronic parts.

Pérez-Belis et al. (2013) collected a sample of unwanted toys and classified them into two main categories: WEEE and Non-WEEE. The toys were further classified into subcategories. These subcategories largely follow the same categories that are used in industry which is based on the toy's shape, form and function. As the research focused in end-of-life small electronic toys, there are no data or non-electronic toys, however it was revealed that 88% of electronic toys collected are in fact non-electronic components. Results also revealed that polystyrene is the most common materials in toys and that is the same case even when toys are sorted into their subcategories (Figure 3-10 and 3-11).

Table 3-5 Percentage weight of toy composition (Adapted from Solé et al. 2012)

Fractions in the recycling process	Toys Composition (%)
Mixed non-metal	76
Iron Metals	13
Non-iron Metals	9.5
Circuit boards	0.5
Batteries and Accumulators	1

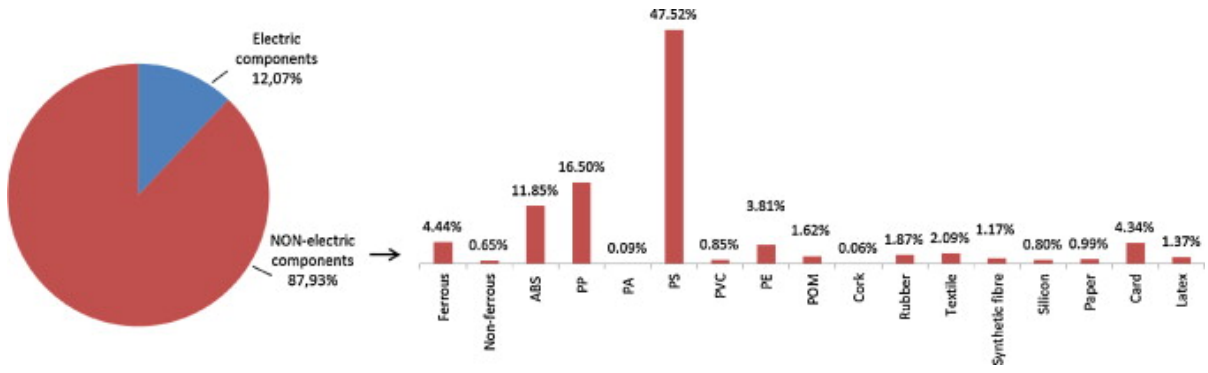

Figure 3-10 Percentage of components and materials by weight

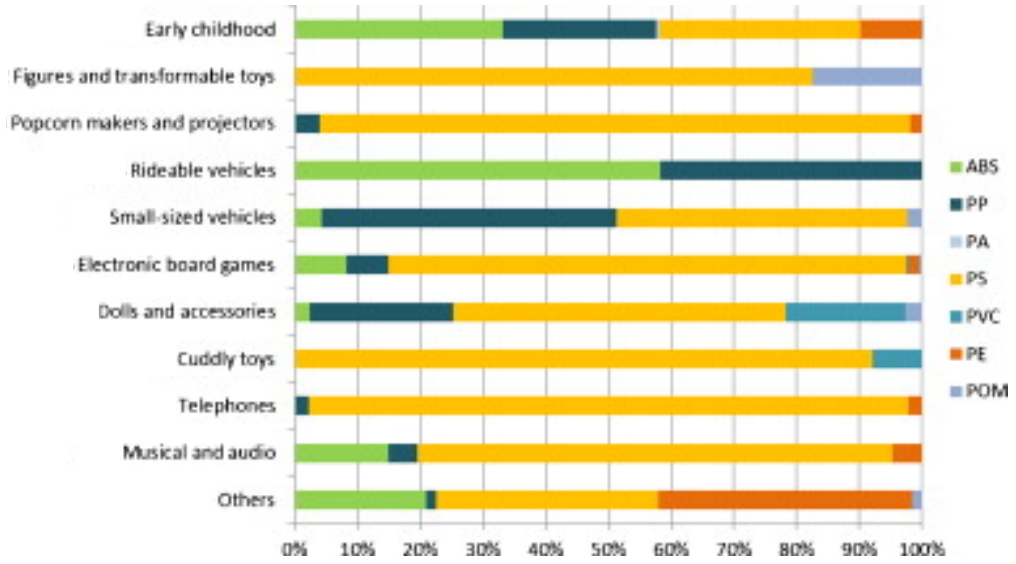

Figure 3-11 Percentage of polymers for each subcategory by weight

3.4.5 Toys Safety Directive and Standards

The 2009/48/EC Directives, commonly known as Toy Safety Directive 2009 (2009 TSD), was developed due to rapid technological developments in the toys market. 2009 TSD updated and completed the safety requirements of toys in particular areas such as noise and chemical in toys and the choking hazards presented by toys in food. These updates were made upon experience gained from the operation of the "old" 88/378/EEC Directives (1988 TSD). The 2009 TSD officially entered into force on 20th July, 2009. As of 20th July, 2011, toys placed on the market will be applicable to the general provisions of TSD 2009, while there was an additional 2 year transitional period for the applicability to the chemical provisions. (European Commission, 2012)

Article 2 from 2009 TSD covered the scope of the directive and provides a definition of toys that falls under the scope of the directive. Toys are defined as "any product designed or intended, whether or not exclusively, for use in play by children under 14 years of age". The wording "whether or not exclusively" indicated that the product does not need to be solely intended for play in order to be considered as a toy, double function products that can be played are also within the scope of the directive. Example of such products can be Christmas tree decoration, key ring in the shape of a doll, soft filled animal shaped backpacks, etc. Along with Article 2, Annex I from 2009 TSD outlined the list of products that are not regarded to be in the scope of the toys considered in the directive.

A list of specific safety requirements were defined and explained in Annex II from 2009 TSD. The requirements were categorised into six main labels; physical and mechanical properties, flammability, chemical properties, electrical properties, hygiene and radioactivity.

The requirements outlined in 2009 TSD were transposed into the EN 71 Safety of Toys standards (NBN EN 71-1, 2011). The standards were divided into eleven parts originally with the addition of EN 71-12 introduced in 2013. Each part of EN 71 charted specific requirements for certain aspect of toys. And relevant parts would be applied to toys in the market, in most cases part 1, 2, 3, 4, 5, 8 and 12 (Table 3-6)

Each part of EN 71 specifies requirements and testing methods for particular aspect of toys. The standards requirements refer to new toys taking into account the period of foreseeable and normal use, and the toys are used as intended or in foreseeable way, with consideration of normal behaviour of children.

Table 3-6 Safety of toy standards EN 71

EN 71	Aspect of Safeties
Part 1	Mechanical and physical properties
Part 2	Flammability
Part 3	Migration of certain elements
Part 4	Experimental sets for chemistry and related activities
Part 5	Chemical toys (sets) other than experimental sets
Part 6	Graphical symbol for age warning labelling
Part 7	Finger paints - Requirements and test methods
Part 8	Swings, slides and similar activity toys for indoor and outdoor family domestic use
Part 9	Organic chemical compounds (limits)
Part 10	Organic chemical compounds (preparation of samples)
Part 11	Organic chemical compounds (testing)
Part 12	N-nitrosamines and N-nitrosatiable substances

It is worth noticing that toys do not need to fulfil the EN 71 standards to be sold in the UK as long as they meet the requirements of 2009 TSD. Toys in the UK market that bear the CE mark would have been declared to have met the requirements of TSD 2009. Toys that follow the British Toy and Hobby Association code of practice and guarantees that the toys meet the requirements of EN 71 will bear the Lion Mark (Department for Business Innovation & Skills, 2011).

EN 71 is the main safety standards in the toy industry, however there are also a bunch of related standards and directive that might apply to certain toys:

Electronic Safety

- Directive 1999/5/EC Radio- and tele-terminal equipment (R&TTE)
- Directive 2004/108/EC Electromagnetic Compatibility (EMC)
- Directive 2006/66/EC Batteries
- EN 62115:2005—Electric Toys-Safety IEC 62115:2003 (Modified) + A1:2004
- Directive 2006/95/EC Low voltage

Chemical safety

- Regulation 1907/2006 REACH (Registration, Evaluation and Authorisation of Chemicals)
- Regulation 1272/2008 on classification, labelling and packaging of substances and mixtures (CLP)
- Directive 2011/65 RoHS (Restriction on the use of certain Hazardous Substances in electric and electronic products)
- Regulation 1223/2009 on Cosmetics

Food contacting safety

- Regulation 1935/2004 on materials and articles intended to come into contact with food
- Regulation 10/2011 on Food contact plastic materials and articles

Waste regulations

- Directive 2012/19 WEEE (Waste Electrical and Electronic Equipment)
- Directive 2008/98/EC on waste
- Directive 94/62/EC on packaging and packaging waste

3.5 Chapter Summary

This chapter described the background and initial development of sustainability. It highlighted the issue of resource depletion and its future implication to society. Product design theories and practises are reviewed, concepts of design for sustainable development and design strategies for resource management was further discussed. lastly, background information of the toy industry was reviewed, including their market, practises, categorising methods, typical materials, and safety regulations for their products.

Chapter 4 Sustainable Design Tools and Life Cycle Assessment in the Toy Industry

4.1 Introduction

This chapter reviews sustainable design, sustainable design tools, specifically life cycle assessment, and how these tools have been applied in the toy industry. The chapter begins with the background and evolution of sustainable design. It is followed by a description of the strategic framework of sustainable design. The factors considered in sustainable design and sustainable design tools that are used are also reviewed. The second part of this chapter focuses in one of the most widely used sustainable tools, namely life cycle assessment. The structure of the life cycle assessment framework is described. The limitations of life cycle assessment surrounding its use of functional unit and boundary selection are also discussed. the last part of this chapter reviewed life cycle assessment and other sustainable design tools that are used in the toy industry. It highlights the limitation of CSR in practice and some common CSR themes across global toy companies.

4.2 Sustainable Design – Current Tools and Methods

This section explores the evolution of the Sustainable Design (SD) processes, their influences in the development of SD strategic frameworks and the translation of SD concepts into practical SD tools. It is known that embedding sustainability into product design is an area of immense potential for improving the environmental impacts of a product across its life cycle. The design phase of development alone is responsible for the majority of the environmental impact of a product. It (Fabrycky, 1987; Keoleian and Menerey, 1994; Poudelet et al., 2012; Tischner, 2001). Otto & Wood (2001) further pointed out that approximately 80% of a product's total impact is determined after merely 20% of the design activity has been carried out. Figure 4-1 highlights this cumulative 'lock-in' effect of sustainable impact of a product over the course of its lifecycle (Lewis et al., 2001). It demonstrates that decisions and actions for environmental improvement need to be initiated as soon as concepts are being generated. This is more commonly referred as the 'design paradox' (Poudelet et al., 2012). It arises due to product

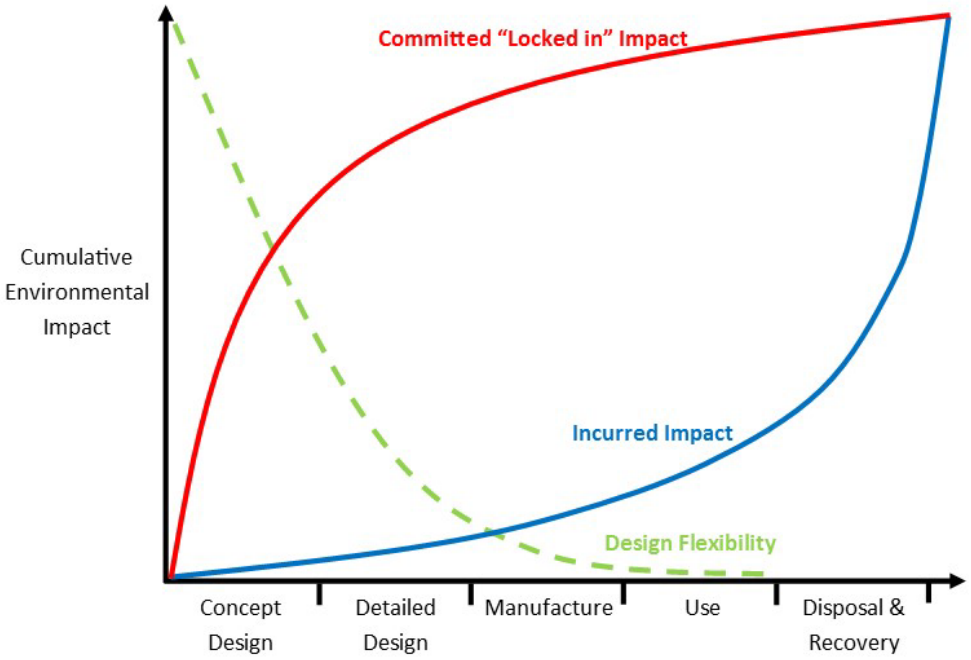

Figure 4-1 Conceptual representation of environmental 'lock in' effect over a product's lifecycle

knowledge building up during early phases of product development, which locks-in the impacts because of decisions taken. Similar effect is observed in determining the cost of a product, to which the incurred cost in testing and production are actually committed in the product development phases (Anderson, 2001; Rebitzer, 2002). This demonstrates a huge potential for incorporating sustainable strategies in conventional product design, and also reveals the SD activities are highly influential to determining the impacts of a product, thus should be applied early on in the product development process.

4.2.1 Evolution of the Sustainable Design Processes

SD started with the integration of environmental factors into the typical product design processes. Design for Environment (DfE) was one such methodologies described in "Design for X" (DfX) (Kuoa et al., 2001; Leonard, 1991). These methodologies were developed base on the framework of Design for Assembly (DfA) (Boothroyd et al., 1994). It outlined a simple and transferable framework for integrating specific consideration into the design process. The tools described in DfX originally aimed to improve quality and reduce cost in manufacturing and to incorporate end of life considerations in product design. The two aims were driven by rising material costs and emerging extended producer responsibility legislations respectively.

In recent years, sustainability is better understood and there is growth in environmental considerations incorporated in design activities. As a result, the scope of DfE have expanded. DfE is often referred as "eco-design"; the term is often used for tools and approaches that focus on improving the ecological attributes of a product. Design for Sustainability (DfS) or SD has been developed which encompasses economic and social considerations as well as environmental. The framework is built upon the eco-design concepts and aims to initiate and establish solutions that consider the entire life cycle of the product (Bhamra and Lofthouse, 2007)**.** Spangenberg et al. (2010) highlighted the differences and challenges in expanding eco-design approach into SD approach (Figure 4-2).

4.2.2 Sustainable Design Strategic Framework

The original sustainable approach can be traced all the way back to when William Morris and his fellow pioneers raised concerns during the industrial revolution. Little or no actions were taken until the 1960s and 70s when designers Victor Papanek and Richard Buckminster Fuller raised concern for the environment (Fletcher and Goggin, 2001). Their efforts for socially and environmentally conscious design are usually regarded as the initiation for SD. This is followed by the development of green-design or eco-design, thus the expansion into sustainability in design (Keitsch, 2012)**.** The principles proposed by Papanek, (1971) and Buckminster Fuller, (1981) have been incorporated into many sustainable design philosophies and frameworks to come.

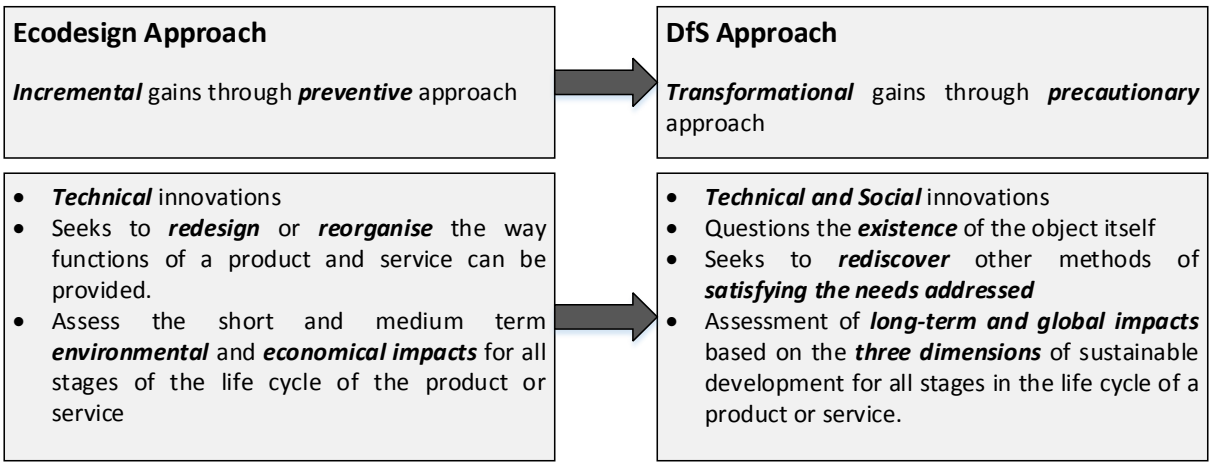

Figure 4-2 Challenges of design for sustainability (Spangenberg et al., 2010)

Charter and Tischner, (2001) reviewed these sustainable design frameworks: Datschefski's "Cyclic-Solar-Safe" principles, which attempts to drive towards fully or mostly relying on renewable resources (Datschefski, 2002). McDonough & Braungart's Hannover Principles' biological and technical metabolisms, which focus on products of consumption and products of service respectively (McDonough and Braungart, 1998). And the Walker principle which focuses on economics, environmental, ethics and social issues (Walker, 2006). These three are among a number of frameworks developed. From the frameworks mentioned above, key areas for reducing sustainable impacts are summarised as follow:

1. Select low impact materials – choose materials that are abundant, recycles, natural, etc.
2. Design products to use no or minimal hazardous materials and/or chemicals – reduce toxic, inflammable, ozone depleting, etc. materials.
3. Use cleaner manufacturing processes – waste and emission prevention is better than an "end of pip" solution.
4. Minimise use of energy and water – reduce demand by choosing designs that require less water and/or energy intensive processes due to material and process choice.
5. Design to minimise waste – reduction is the most preferable part of waste management hierarchy. When reduction is not applicable, avoid energy recovery (incineration) and attempt to re-use or remanufacture.

Additionally, several organisations have emerged in recent years, in order to further support and integrate sustainable design philosophies into traditional design processes. They brought together practitioners of SD to share ideas and gain expertise (Spangenberg et al., 2010)**.** The Designers Accord is one example that encourages practitioners to "*adopt a 'Kyoto Treaty' of design that specifies a particular ethos and behaviour around SD*" (Figure 4-3) (The Designers Accord, 2007). As the domain of environmental design evolved and expanded into sustainable design, one can only assume that the scope of design considerations will continue to grow and encompasses a wilder set of concerns that will hopefully identify solutions for this global challenge.

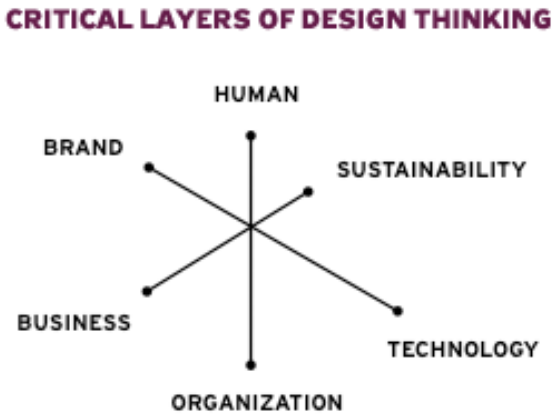

Figure 4-3 The Designer Accord Design Approach (The Designers Accord, 2007)

4.2.3 Sustainable Design Factors

While the SD frameworks provide guidelines for design approaches, it is also important to comprehend the sustainable considerations for a product and integrating them into the long lists of conventional product design factors that is shown in Figure 4-4. Over the years, the critical sustainable factors for design consideration have been well researched and subsequently been collated and edited in a number of books that provide straightforward guidance in conducting SD (Bhamra and Lofthouse, 2007; Lewis, H. et al., 2001; Walker, 2006) One example of incorporating SD considerations into conventional design factors is Luttropp & Lagerstedt's EcoDesign and The Ten Golden Rules: generic advice for merging environmental aspects into product development. Luttropp & Lagerstedt (2006) outlined ten "rules" that follow the life cycle of a product (Figure 4-5). These rules are intended to generate specific consideration for each area, and are supplemented with guidelines and examples for application. It has been found, though, that in practice SD process often only considered one to two sustainable factors, instead of attempting to cover the entire life cycle of the products (Ehrenfeld and Lenox, 1997). Many studies also pointed out that successful incorporation of SD considerations is those that were included early on and throughout the entire product development process (Deutz et al., 2013; Lofthouse, 2004). Therefore many studies proposed that sustainable factors should be embedded into the product design considerations as part of the multi-criteria approach, instead of being a separate add-on consideration (Bovea and Pérez-Belis, 2012; Kaebernick et al., 2003; Luttropp, 2001; Sherwin and Evans, 2000).

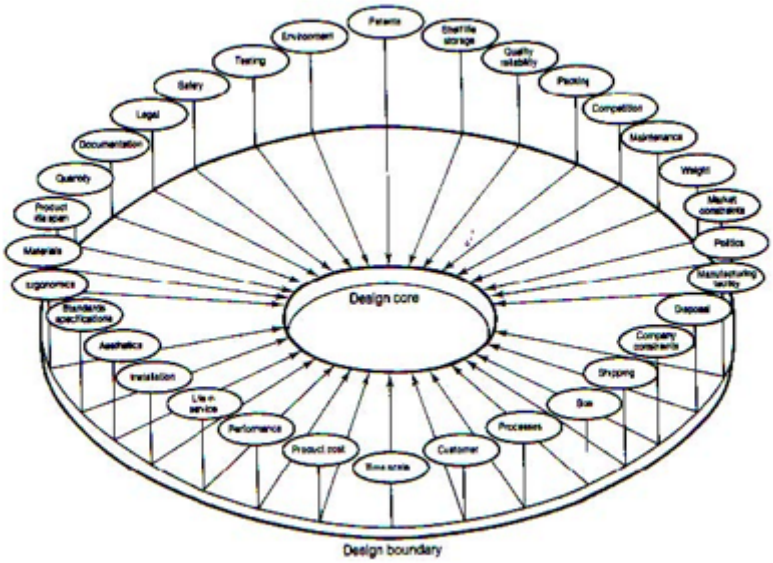

Figure 4-4 Conventional design considerations (Pugh, 1992)

Figure 4-5 Ten Golden Rules "Swiss Army Knife" Approach (Luttropp & Lagerstedt, 2006)

4.2.4 SD Tools

There are an extensive range specific, independent SD tools available. These tools can be employed to ensure smooth incorporation of SD considerations into product development. These enable sustainability to be properly considered during product design and provide recommendations for more environmentally and socially conscience decisions. However, only

a handful of these tools actually consider the social factors, thus many existing tools should really be labelled as eco-design tools rather than scope-expanding SD tools.

Existing tools can be grouped into six main categories depending on their approaches (Baumann et al., 2002). Table 4-1 shows these categories and examples of their corresponding tools. These tools are normally applied at separate phases within the design process, and they focus on different aspects of the product life cycle with varying sustainable priorities (Ehrenfeld and Lenox, 1997). For instance, the MET matrix (Material, Energy and Toxicity) specifies a checklists for structured analysis against guiding principles (Brezet and van Hemel, 1997). MET matrix is often applied from the initial design phase, then along the entire design process. Its analysis also encompasses the product's complete life cycle. Whereas, Design for Recycling (DfR) provides conceptual guidelines for best practices (Henstock, 1988). It is typically applied at the detail design phase and only concentrates on the end of life of a product. These tools require different type of input data, and presents different output for specific use. They also require varying length of time to be completed depending on their complexity.

Because of the SD tools' separate focuses and their specific inputs and outputs, they can be used as stand-alone tools as well as a compilation of tools to be applied concurrently. Some researches even attempt to combine the tools for a more comprehensive analysis. For example, there is a range of methods on combining Life Cycle Analysis (LCA) and Life Cycle Costing (LCC) together (Norris, 2001; Rebitzer, 2002).

It was found that a number of companies set up their own version of SD tools to tackle their specific critical issues that were flagged up (Luttropp and Lagerstedt, 2006), this is less time consumping as the specifically developed tool can fit within existing prodedures. Several other SD tools have also been developed from existing design tools, by integrating environmental requirements into product design process (Bovea and Pérez-Belis, 2012). They can be classified into five groups; matrix based design, Quality Function Deployment (QFD) based, Value Analysis based, Failure Mode and Effects Analysis (FMEA) based and others. Some example may be Environmentally Consicious QFD**,** Eco-QFD, and House of Ecology (Halog et al., 2001; Kaebernick et al., 2003; Vinodh and Rathod, 2010).

Table 4-1 Sustainable design tools categories and methodologies examples

CATEGORY	DESCRIPTION	EXAMPLE METHODS/TOOLS
Frameworks	Offer general guiding ideas about key considerations that should be taken into account.	***Corporate Social Responsibility*** ***Cradle-to-Cradle*** ***Design for X*** *(DfX)* *- Recycling (DfR)* *- Life Cycle (DfLC)* *- Environment (DfE)*
Analytical Tools	Comprehensive, quantitative tools for evaluating and measuring the environmental performance of products.	***Life Cycle Analysis*** *(LCA)* ***Social Life Cycle Analysis*** *(S-LCA)* ***Life Cycle Costing*** *(LCC)* ***Risk Analysis***
Checklists and Guidelines	Qualitative tools used to check whether the product is meeting a set of targets or requirements. Can also be semi-quantitative if they incorporate numerical performance criteria.	***MET Matrix*** ***10 Golden Rules*** ***Phillips Fast Five***
Rating and Ranking Tools	Simple, quantitative tools, which utilise a pre-specified scale for assessment allowing direct numerical representation of simple metrics.	***Eco-Compass*** ***ERPA*** ***MiPs*** ***LiDS Wheel*** ***Econcept Spiderweb*** ***Eco-Indicator 99 Worksheets*** (PRé Consultants)
Software and Expert Systems	Intended to be simple to use and to handle large amounts of environmental information, avoiding the need for elaborate data collection.	***SimaPro*** (PRé Consultants) ***GaBi*** (PE International) ***ECO-it*** (PRé Consultants) ***PILOT***
Organising Tools	Give direction on how to optimally organise tasks.	*Custom and specific.*

Four common themes can be identified and concluded from the reviews of these SD tools:

- Tools are often applied at the latter phases of the design process, which have less influences in reducing sustainable impacts of the products (Ehrenfeld and Lenox, 1997), as the impacts were determined or "locked in" early on in the design process (Poudelet et al., 2012; Rebitzer, 2002).
- A considerable number of tools only address one single sustainable objective with very few taking account of the entire lifecycle (Ehrenfeld and Lenox, 1997)
- Tools require a huge amount of knowledge, need extensive data screening, and are very time consuming in most cases (Ehrenfeld and Lenox, 1997; Wright and Rahimifard, 2012)
- Tools' analytical results may indicate contradicting considerations and complicated trade-offs with little indication for decision making priority (Ehrenfeld and Lenox, 1997).

These points highlighted the limitations of existing SD tools. It clearly pointed out that SD strategies and tools should be fully integrated in the design process early on, where impacts and costs are determined and locked in. This view is echoed by Ehrenfeld & Lenox (1997) remarks, stating that these stand-alone tools "are not sufficient and perhaps not even necessary for efficient". While eco-design strategies have successfully expanded their scope into SD strategies that encompasses ESE considerations, there are few existing tools that fully address all sustainable factors. The existing tools are still under-developed as compared to their environmentally focused counterparts and they are not comprehensive enough to be fully utilised Brent and Labuschagne, (2006) and Macombe et al., (2013).

4.3 Life Cycle Assessment

LCA is widely regarded to be a well-developed methodology for assessing environmental sustainability. It quantitatively evaluates the environmental impacts of a product and/or a service. The International Standards Office has constructed a standard methodology in the form of ISO: 14040 and ISO: 14044 (ISO, 2006a, 2006b). As its name suggests, LCA apply a holistic, all-encompassing approach to assess a product and/or a service throughout its entire life cycle: from raw material extraction through to product disposal. Figure 4-6 shows the four

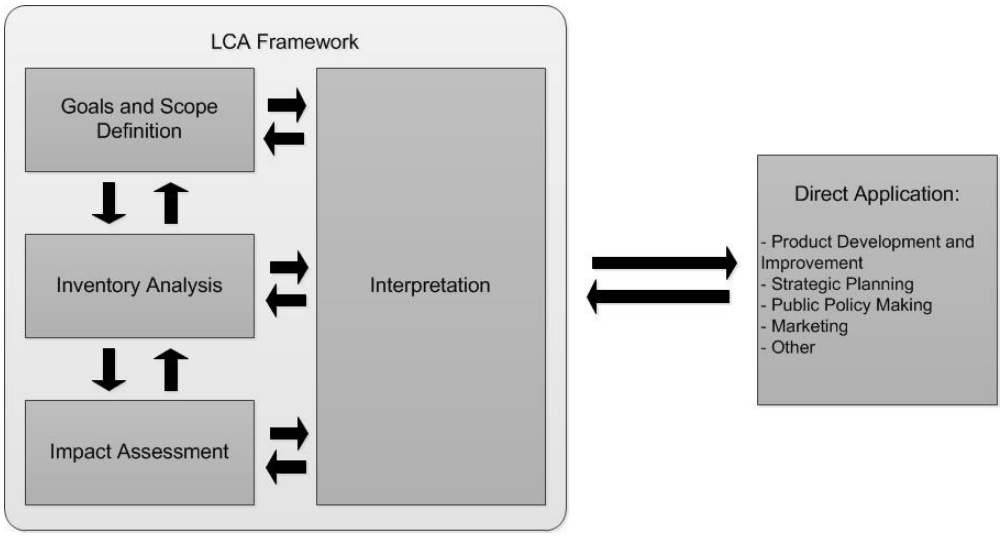

Figure 4-6 LCA framework

distinct LCA phases; Goal and Scope Definition, Inventory Analysis, Impact Assessment, and Interpretation.

The purpose of LCA studies are defined in the goal and scope definition phase, along with system boundary and any assumption stated. It is also the phase where a functional unit is set. A functional unit is used as a reference to analyse and compare different products. It is a clear precise statement that describes the service of a product where inputs and outputs can be related, i.e. A device to boil 1 litre of water twice a day for three years (Rebitzer, 2002). The second phase is inventory analysis where energy, raw materials, and emissions for the entire life cycle of a product are quantified. This is typically the most time-consuming phase. The third phase is the impact assessment where impact categories are identified and applied to the inventories listed from the second phase. Interpretation is the final and fourth phase, where results are analysed and verified, and opinions and conclusions are drawn from the study. However, LCA is by no means the most comprehensive assessment tool. There are still a lot of unresolved limitations to all 4 phases of LCA as shown in Table 4-2. It is easy to spot that current LCA only consider environmental issues, assessments for the other two pillars of sustainability required other tools.

Table 4-2 LCA limitations

Phase	Limitation
Goal and scope definitive	Functional unit definition Boundary selection No social and sconomic decision Alternative scenario considerations
Life cycle inventory analysis	Allocation Negligible contribution criteria Local technical uniqueness
Life cycle impact assessment	Impact category and methodology selection Local environmental uniqueness
Life cycle interprutation	Weighting and valuation Uncertainty in decision process
All	Data availability and quality

4.3.1 Functional Unit Limitation

Functional units is the essence of a fair comparison between LCAs of product, however it is difficult to define a comprehensive functional unit that includes multiple functions (Finkbeiner et al., 1997; Ruhland et al., 2000). Functions of product are sometimes difficult to quantify as well. Functional unit is rather limited to handle more ambiguous functions, which makes it hard to define and compare (Cooper, 2003). Examples of this limitation are functions such as the aesthetics properties and sentimental value provided by a product. This issue has a greater influence on the effectiveness of a social assessment as compared with an environmental assessment. This is particularly relevant as the entertainment and education a child gets from playing with toys are difficult to measure and compare (Reap et al., 2008).

The presence of a functional unit enables comparison between products, however two products that have different functions may not be comprehensively reflected as the a vague common function was forced to be used for the assessment (Hischier and Reichart, 2003). This limitation deems LCA to be ineffective while resources distribution decisions are to be made, either at a corporate level where executives must decide on different product ranges or at a legislative level where governments must decide on what companies get the competing resources.

4.3.2 Boundary Selection

This is a limitation that is similar to limitation of comparison. It makes it difficult to compare products with or without a common function, when the boundary is completely different. And only experienced practitioners will be able to identify over "cut-off" which affect the results of assessment greatly (Reap et al., 2008). An example of this may be the presence of batteries in assessments for electronic toys, where the batteries heavily influence the recommendation for redesign activities while there are other issues to be addressed as well (Catalan Waste Agency, 2008; Muñoz et al., 2008).

4.3.3 Geographical Uniqueness

Inventory and impact data are hard to be obtained and the existing data are used for all general purposes, which raises the issue with geographical fit of the assessment. A lot of the impacts are actually closely related to regional influence which LCAs fail to address the uniqueness (Kerwitt et al., 2001). The geographical uniqueness will affect the social assessment even greater, as specific ethical and cultural differences are less well-known.

4.4 LCA in the Toy industry

Although LCA has been applied in a plethora of cases across multiple industries, there are only a handful of LCA studies carried out on toys. While the principle of LCA and the suggested practices recommend a transparent methodology and reports, most LCA studies that are claimed to have carried out by global toy companies are not publicly available. Several common actions were identified as suggestions in the LCA studies from CSR reports of major global toy manufacturers: reduction in carbon emission, reduction in waste, material substitutions, and reduction in packaging materials. There are four other LCA studies carried out. LCA studies on four electronic toys (Catalan Waste Agency, 2008). The redesign suggestions from these studies mostly aligned with the ones from CSR reports of toy corporations. It had to be pointed out that the presence of batteries in electronic toys have greatly influenced the results of these studies.

End-of life management system was proposed for used toys (Bovea and Pérez-Belis, 2012; Solé et al., 2012). These researches provided valuable knowledge and information of end-of-life scenarios in future studies. Solé et al., (2012) calculated the impacts avoided in reuse and recycling scenarios, however that cannot be used as a standalone study for sustainable toy redesign. In general, there is a lack of researches in LCA case studies of toys, this may be

because of the difficulty in data collection due to the long life-cycle of toys and the traceability of playable toys.

4.4.1 Corporate Social Responsibility

Researches carried out in the 90s have broadened the scope of investigation to include social and cultural concerns as well as environmental issues. They are normally depicted by the terms "social" or "ethical" responsibility. Vogel, (2005) highlighted the need to include social factors, such as poverty, health, and child welfare, into sustainable considerations within business management with the use the two cases; the cases of the dispute between the Ogoni population and Shell in the early 90s and the well documented case of NIKE's employment of child labour in Pakistan in the mid-90s.

One of the tools available for encompassing these social and ethnic responsibility is Corporate Social Responsibility. It utilises a "top-down" approach for management within a corporation to set initiatives to drive sustainability, as opposed to a "bottom-up" approach like LCA that assesses products and services to inform and support strategic decisions. CSR is developed as a paradigm switch from regulatory governance to voluntary initiatives and corporate self-regulation to achieve sustainability over the last two decades. Many corporations and businesses welcome these ideas of partnership and co-regulation instead of a traditional "command and control" approaches.

CSR is a framework that allows companies to demonstrate their commitment to identify and minimise their negative impacts associated with their operations, which affect society and environment. The framework, in theory, should encompass all three dimensions of sustainability. Upon reviewing literatures of CSR, 6 common features have been identified:

(i) going beyond legal requirements and duty to shareholders being voluntary in nature (Bloom and G.T, 2001) (European Union, 2001)

(ii) meeting responsibilities to internal and external stakeholders (Maignan and Ferrell, 2000)

(iii) integration of social and environmental concerns into business operations (Van Marrewijk, 2003)

(iv) optimising positive effects and minimising negative effects of the company's actions (Lantos, 2001)

(v) objective concern for the welfare of society (Hartman, 1998)

These features are well accepted, and nowadays it will be hard to find a major corporation reports without some form a CSR reporting. This also highlighted the important business case for CSR (Carroll and Shabana, 2010; Vogel, 2005). The typical activities applied by companies are summed up in 6 areas (Rapson et al., 2007):

- Statement containing explanation of Socially responsible investing in relation to investment activities, outline of actions and objectives
- Identifiable staff responsible for CSR products and services
- Publish regular reports of CSR activities/performance
- Inform CSR criteria and product development through regular committee meetings (external and internal staff)
- Offer service to institutional investors which targets engagement activities in accordance with individual organisations' preferences
- Certification programmes and voluntary standards

These activities typically involve setting policy statements, advisory committees, reporting and certification schemes. Reporting and certification are normally endorsed by external third party while the other activities are carried out internally. The first three activities are normally covered in the first part of the report which highlights the corporate responsible governance structure, responsible staff, and the report structure along with key performance highlight and future goals. There has been a steady rise in corporate social reporting since 1990s, growing from less than 100 companies to more than 500 in 1999 (Vogel, 2005). Despite this increase, it is worth pointing out that some standards are mere expressions of principles without mechanism for implementation, monitoring or verification of compliance. However, existing standards on reporting can be easily manipulated, companies often chose what to report on. Whereas, some detailed a more thorough process of examining, measuring and testing for compliance to a specified requirement (Font and Bendell, 2002).

Many researches pointed to the voluntary nature of CSR as the driver for integrating social and environmental considerations into core corporate activities. However, other have differing views, pointing out that the criteria set in CSR reporting and certifications are often

set beyond financial and technical capability of many SMEs. As a result, CSR are often limited to bigger organisations (Kinderyte, 2008). Furthermore, many standards for corporate human rights are ill-defined, while investments in monitoring these issues tends to be media, public relation driver (Vogel, 2005).

Fundamentally, CSR is more than often used as a smoke screen to demonstrate all the "positive" activities while masking all the other impactful activities. Perhaps Porritt (2005) give the most perfect summary in this fundamental limit of CSR practice:

The very fact that the majority of companies still opt for CSR (or, increasingly, just 'CR' without the 'S') as the self-contained box into which to pack all their 'good stuff', while they continue to pursue their core business (quite legally and, indeed, quite logically, given the failure of politicians to change the rule) without the remotest likelihood that they or their products/services will ever become genuinely sustainable, reveals all one really needs to know about the empty, seductive illusion that is CSR (Porritt, 2005)

4.4.2 Current Sustainability Effort and CSR in the Toy Industry

Current sustainable efforts in the toy industry are not well documented. Any major news coverage tend to be in the form of reaction to bad press, such as the Mettel lead paint incident(Gilbert and Wisner, 2010) and the recent industry exodus of using PVC dues to mild toxic phthalates (Grynkiewicz-bylina, 2011; Robbins, 2013; Saikia et al., 2010; Tickner, 1999). Even in these cases, the change in design and practice are more likely to be driven by health and safety of the product, thus public relation.

This is not to say that the toy industry is at a standstill in regard to sustainability. There are efforts in sustainability and they are evident in CSR reports from the major global toy companies. Six major global toy companies' CSR reports and policies were reviewed (Hasbro, 2011, 2015; Mattel, 2015; The Lego Group, 2012; TOMY, 2013) In general, all the reports follow the findings from above CSR reviews. There is a distinctive lack of negative impacts or failures recorded on all the reports. Table 4-3, 4-4, and 4-5 summarised the reports into thematic topics of their actions. Three distinctive themes can be distinguished from the reports. The first theme concerns companies' governance and practices, the actions carried out typically involve product safety and health and safety practices.

The second theme concerns environmental sustainability, the actions involved are mostly the same across all six companies. The actions typically involved reduction in water,

energy, and material used. It may also involve reducing carbon emission and waste. Some corporations even set zero emission and zero waste to landfills as their CSR goals. The third theme is social and ethical responsibility, this would involve some community engagement projects and staff volunteering schemes. Apart from the case of Lego, it is difficult to claim that these corporations are "*going beyond legal requirements and duty to shareholders*", instead of performing to the reequipments. As the nature of CSR is about corporate governance, the projects relating to societies do not relate to the impacts of their products either. The toy products are being used as instrument in these projects, but their inherent impacts are not clear.

Activities in all these areas are all beneficial, and certainly contribute towards sustainable development as a whole. On the other hand, because of the unique nature of CSR reporting, a comprehensive in-sight into all the sustainable activities are difficult, as companies tend only to report on the easily quantifiable and achievable goals. On top of that, because of the competitive nature of the industry, companies are rather guarded on what they report on.

While being resource efficient, using recycled materials and prolonging product use life are all typical sustainable strategies, they do not actually address the continuous consumption of resources. All the activities have driven towards environmental sustainability while in fact the toy industry seems to have positioned itself to be a more socially influenced industry as opposed to environmentally driven. The nature of toys means that there are much existing discussions on the social influences or impacts inherited in the product, environmental concerns seem to take less of a spotlight as compared to other industry. There is a need for promoting social value assessing methodologies and strategies.

Table 4-3 Common themes of CSR reports from major toy companies (Corporate Governance & Management)

Company	***Takara Tomy***		***Bandai Namco***		***Lego***		***V-Tech***		***Mattel***		***Hasbro***	
Report Title	CSR Policy		CSR Activity Report				Sustainability Report 2016		Citizenship Report 2012		CSR Report 2015	
		Sub categories		**Sub categories**		**Sub categories**		**Sub categories**		**Sub categories**		**Sub categories**
Corporate Governance & Management	**Product Quality**	Product Safety	**Safety & Cleanliness of Products & Service**	Product Safety	**Children**	Digital Child Safety Policy	**Product Responsibility & Innovation**	Provide Well-being through Product	**Our Company**	Governance Structure	**Product Safety**	Total Quality
		Customer Service		Production Health & Safety		Responsible Marketing to Children		Health & Safety		Code of Conduct		Chemical Safety Reform
		Accessible Design		Safe Delivery		Children's Right		Follow LCA guidelines	**Our Products**	Product Quality & QMS		
	Management	Human Capital	**Supply Chain Management**			Eliminate Child Labour	**Workplace Quality**	Communication & Staff Relations		Product Safety		
						Product Safety		Advancement in Career		Ethical Manufacturing		
								Labour & Human Rights		Sustainable Sourcing		
								Pleasant & Healthy Workplace				
							Sustainable Operating Practices	Risk Management				
								Supply Chain Management				
								Procurement Practice				
								Climate Change Policy				

Table 4-4 Common themes of CSR reports from major toy companies (Social & Ethical Responsibility)

Company		***Takara Tomy***		***Bandai Namco***		***Lego***		***V-Tech***		***Mattel***		***Hasbro***	
Report Title		CSR Policy		CSR Activity Report				Sustainability Report 2016		Citizenship Report 2012		CSR Report 2015	
		Sub categories			**Sub categories**		**Sub categories**		**Sub categories**		**Sub categories**		**Sub categories**
Social & Ethical Responsibility			**Policies Regarding Influence on Society of the Group's Content & Products**		Control of Ethical Expression in Content and Products	**Society**	Community Engagement	**Community Investment**	Volunteering Scheme	**Social Impact**	Community Engagement	**Human Rights**	Worker Collaboration Tool
					Appropriate Expression		Workplace Safety		Charity Support		Providing Play Opportunity		Community Engagement
					Ethical Checks of Expressions & Terminology		Employee Mental Health Care		Training for Young People		Supporting Children Play Learning & Development		Fair Gender Advancement Opportunity
							Auditing		Nourish Innovative Environment	**Our People**	Ethnic Equality		Volunteering Scheme
							Ethnical Equality		Develop Healthy & Green Community		Gender Equality	**Ethical Sourcing**	Ethical Sourcing Practices
							Responsible Sourcing						

Table 4-5 Common themes of CSR reports from major toy companies (Environmental Sustainability)

Company	***Takara Tomy***		***Bandai Namco***		***Lego***		***V-Tech***		***Mattel***		***Hasbro***	
Report Title	CSR Policy		CSR Activity Report				Sustainability Report 2016		Citizenship Report 2012		CSR Report 2015	
		Sub categories		**Sub categories**		**Sub categories**		**Sub categories**		**Sub categories**		**Sub categories**
Environmental Sustainability	**Society and Global Environment**	Eco-friendly toys (Eco Mark)	**Environmental Consideration**	Env. Friendly Design	**Planet**	Reduce CO2 Emission	**Environmental Protection**	Reduce Energy	**Sustainability (Env)**	Energy Reduction	**Environmental Sustainability**	Green House Gas Reduction
		Green logistics		Env. Education Activities		100% Renewable Energy		Reduce Carbon Emission		Water Reduction		Reduce Waste to Landfill from Facility
		Education & communication of environmental awareness		Energy Saving		Sustainable Materials		Reduce Water Used		Waste Reduction		Reduce Water Consumption
		Cultural activities & Community Involvement		Recycling		Zero Waste to Landfill		Reduce Material Used & Waste		Increase Recycling		Reduce energy Consumption
				Reduce Co2 Emission		Sustainable Factory		Improve Logistic Practices		Sustainable Sourcing		
										Reduce Carbon emission		
										Reduce Material Used		
										Promote Culture of Sustainable Growth		

4.5 Chapter Summary

This chapter described the background and development of sustainable design. It provided an overview of current state of the art sustainable tools and methods. One sustainable tool was reviewed in more detail; LCA was further studied and limitations of its phases were discussed. lastly, LCAs of toys and current sustainable activities of toy companies were reviewed.

Chapter 5 The Social Consideration in Sustainable Product Design and Benefits of Play

5.1 Introduction

This chapter looks at the social pillar of sustainable design and assessments. It begins with a review of consideration of social factors in sustainable product design. The concepts of positive and negative impacts within sustainable assessments are further reviewed. The lack of formal 'use phase' assessments are also discussed. Social life cycle assessment is identified out to be the tool that is most suitable to encompass positive social impact assessment (SLCA). The next section of this chapter describes the historical background and development of SLCA. The SLCA method is expounded and the two impact assessment methods are further discussed. The definition of positive impact within SLCA researches are reviewed, the methods for assessing such impact are examined. Lastly, one possible positive impacts of products are identified as the benefits of playing with toys. this section of the chapter reviewed researches on play, the definition of play, how different types of play are classified, and the benefits of play are summarised.

5.2 Social Consideration in Sustainable Product Design

There are three distinctive phases of the development of the sustainable design; Green design, Eco-design and Sustainable (Argument et al., 1998; Bhamra and Lofthouse, 2007; Keitsch, 2012). Green design takes into account the impact of the product on the environment, Eco-design aims to minimise environmental impacts while meeting cost, quality and performances goals, and Sustainable design aims to balance environmental, social and economic needs (the triple bottom line). These phases correspond to the continual expansion of the scope of activities to incorporate wider considerations and extra stages of the product lifecycle. The boundaries of design practice and considerations are expanded through the development of each phase, significantly changing the processes and information/knowledge required for SPD. Figure 5-1 illustrates the factors that drove this development and the methodologies and tools that were developed in correspondence to these phases of sustainable design.

Whilst SPD has continued to incorporate a wider scope of considerations, there are little considerations in the social aspect of sustainability. It is widely acknowledged that the three dimensions of sustainability have received differing degrees of attentions (Colantonio, 2007). Review in Chapter 4 highlighted that SPD methodologies and tools have been prioritised the three aspects of sustainability unevenly over the years (Drakakis-Smith, 1995; Marghescu, 2005). Economic considerations are already well advanced in manufacturing companies through the development and use of life cycle costing (LCC) tools, and Lean practices. This is also because economic considerations are key business driver more often than not. Other existing SD tools tend to focus on incorporating environmental considerations into design. Social considerations are often considered in terms of the social implication of environmental politics instead of an equally integral component of sustainability (OECD, 2012b). However, there is a growing need to incorporate social considerations into product development alongside economic and environmental concerns to provide a truly comprehensive SPD process.

For SPD to be fully sustainable, it will require the integration of social factors and the redressing of design to meet the needs of customers and their greater society — societal needs. (The term 'societal' is used in place of 'social' to highlight the nature that it should affect the greater society rather than addressing specific social issues.) This idea is perhaps best summed up by Keitsch (2012) who concluded that *"while approaches before and in the first phase after Bruntland were more or less technology orientated, sustainable design concepts of the new millennium … are characterised by designs' growing concern for socio-cultural sustainability and use innovation."* Notions that are shared in the wider research community (Brown, 2009; Koskinen and Thomson, 2012; Sterling, 2005).

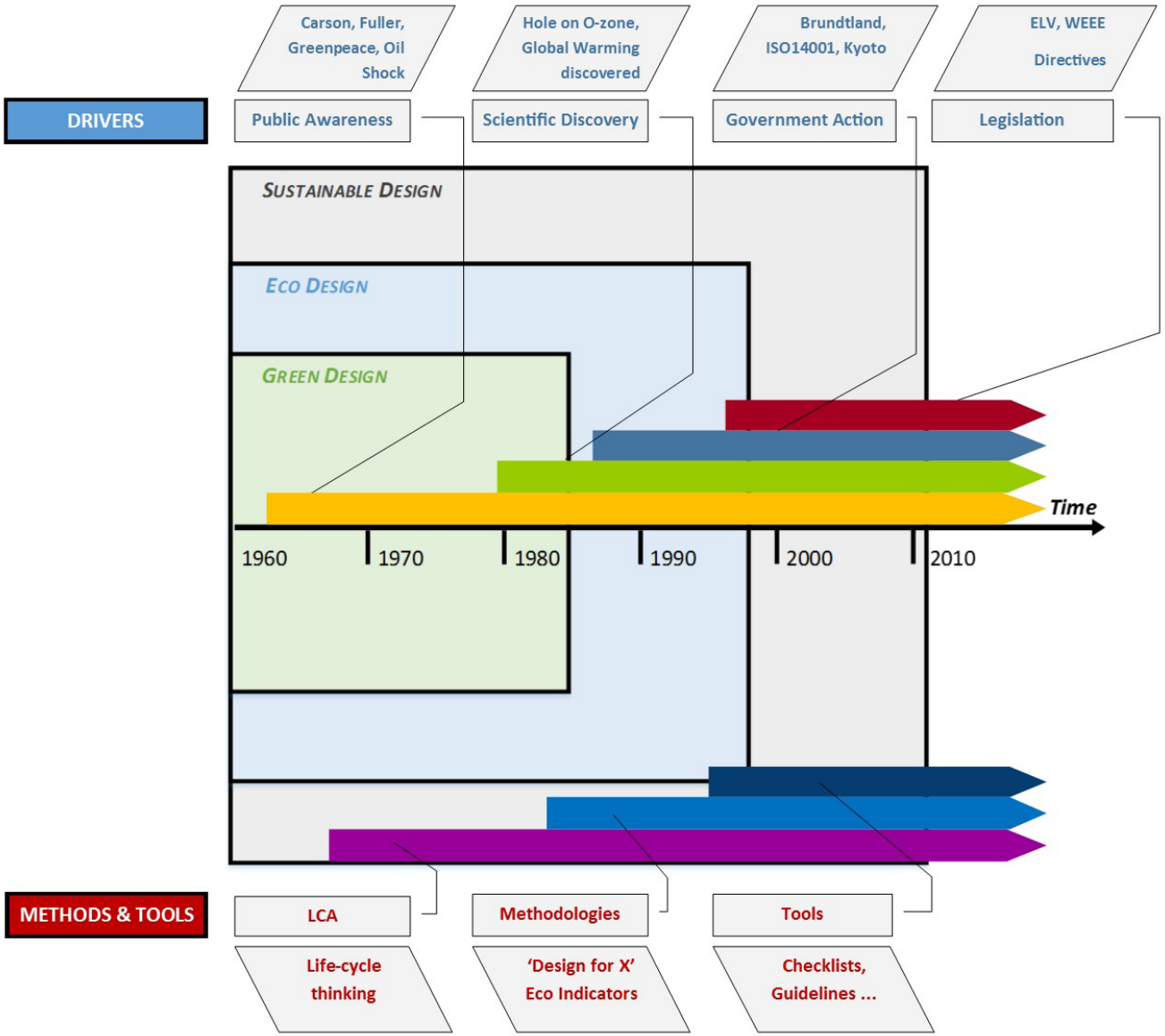

Figure 5-1 Evolution of sustainable design

5.2.1 Social Consideration for Positive and Negative Impacts

As mentioned in previous chapters, the design process effectively determined the impacts of products throughout their lifecycles. These impacts can be detrimental, such as the carbon and toxic substance emissions. However, impacts can also be beneficial; SPD processes have been applied to solve social design problems such as improving healthcare, preventing crime, and promoting good hygiene (Brown, 2009; Kelley and Littman, 2001).While design process can include social considerations along with environmental concerns, SD tools are needed to assess, measure, and improve products in terms of their detrimental or beneficial impacts.

Shin et al. (2015) compiled a list of 108 SD tools and grouped them where positive and negative considerations are involved. The results are shown in Figure 5-2. This indicates that current assessments that evaluate the social and environmental aspects offer little consideration of the beneficial gain of a product, instead focusing mainly on its detrimental loss. This may drive incremental changes towards sustainability improvement, however the enhancement of the social and environmental gain can be more effective. For example, a product could be made more sustainable by reducing its environmental and social impacts, however if the product had little societal benefits, should valuable resources be wasted on its production.

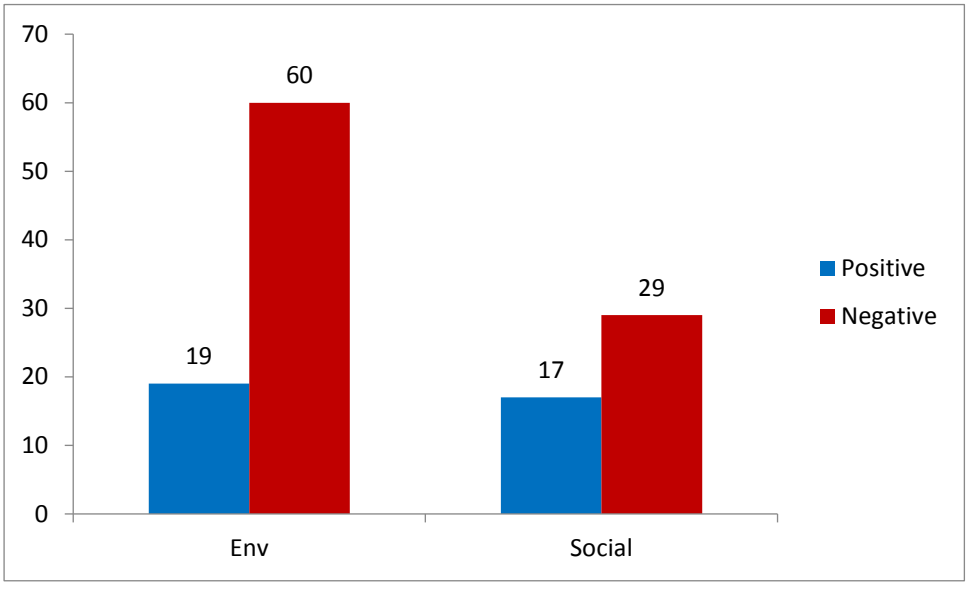

Figure 5-2 Positive and negative assessments of environmental and social assessment tools

5.2.2 Sustainability in the "Use" Phase of Products

One can argue that the societal needs of products are most apparent during the "use" phase of products. After all, the product design process is supposed to address needs. However, DfX approaches have aimed to improve environmental performance around production activities as a first step towards sustainability (Fletcher and Goggin, 2001; Spangenberg et al., 2010). As such, it has been discussed in previous chapter that a large amount of research and work have been carried out in design for "production" and "EOL" phases of a product life cycle. This may be due to ecological, economic, and regulatory factors as well. The "use" phase, on the other hand, has seen little work comparatively. Research in this area is still somewhat new in spite of the fact that the "use" phase of a lot of products is accounted for the primary impactful phase. For instance, 90% of the life cycle energy consumption of household appliances takes place during their "use" phase, and of this consumption, up to 90% is determined in design (Tischner, 2001). It can only be reasonable to believe that it is the same case for societal needs, after all why would/should a product be designed and manufactured if it did not contribute to society's need. This highlights the importance of designing for the "use" phase of products.

5.3 Social Life Cycle Assessment

LCA is often considered to be a valuable support tool in integrating sustainability into product design and evaluation of products due to its systematic approach. Environmental LCA, hereafter referred as ELCA, is primarily considers environmental impacts along supply chains, from extraction of raw materials to the End-of-Life of products. Social life cycle assessment (SLCA) shares the life cycle perspective with ELCA and integrates traditional ELCA methodological steps while having social impacts as focus. Similar to ELCA, SLCA adopted the same framework which is comprised of four main steps: goal and scope, life cycle inventory analysis, life cycle impact assessment, and interpretation.

5.3.1 Historical Development of SLCA

O'Brien et al., (1996) first raised the notion of accompanying ELCA with social considerations assessment. Kloffer (2003) and Weidema (2006) advanced the idea further by proposing ways to integration and alignment of SLCA with ELCA methodology (Klöpffer, 2003; Weidema, 2006). Various indicators have been proposed and implemented, for instance, Quality Adjusted Life Years (QALY) (Weidema, 2006), additional employment (Hunkeler, 2006), and health impacts (Norris, 2006). Dreyer et al., (2006) proposed a site-specific assessment where impacts are directly related to company behaviour.

In 2009, the SLCA guidelines were issued (Benoît and Mazijn, 2009). The guidelines are formulated by an open global process involving stakeholders from public, academic, and business sectors. The guidelines are currently the most established and well-used framework for conducting SLCA. It is a framework with guidelines on several approaches, it is by no means an established tool like its ELCA counterpart. Furthermore, SLCA does not determine whether a product should be made, nor does it provide recommendations on addressing any identified social impacts. It only provides a "snapshot" to support decisions on the production of products.

5.3.2 Social Life Cycle Assessment Methodology

The assessment boundary of SLCA is set in relation to an Area of Protection (AoP). AoP is indicated to be human well-being in the case of SLCA, which, according to the guidelines, is described as the state of an individual's life situation. Impacts on human well-being are assessed in connection to five stakeholder groups that are affected potentially. Figure 5-3 illustrates these stakeholders which are worker, local community, value chain actor, society, and consumer (Benoît and Mazijn, 2009). It is worth of note that the consumer stakeholder is only included in scenarios of retail interaction, whilst impacts during use phase (the core purpose of a product or service) are not considered. Each stakeholder is associated with a number of subcategories, such as fair salary, working hours, and health and safety for the

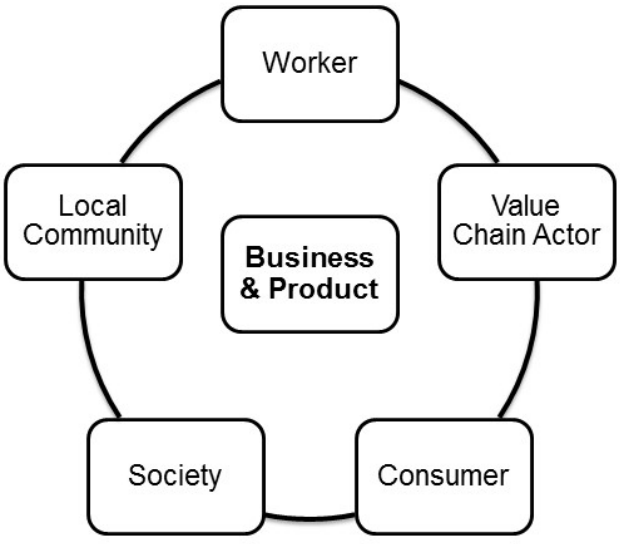

Figure 5-3 Stakeholder groups of SLCA

worker stakeholder, and cultural heritage, local employment, and community engagement for the local community stakeholder. All the stakeholders along with their relating subcategories are presented in Table 5-1.

Table 5-1 Stakeholder subcategories

Stakeholder categories	Subcategories
Worker	Freedom of Association and Collective Bargaining Child Labour Fair Salary Working Hours Forced Labour Equal opportunities/Discrimination Health and Safety Social Benefits/Social Security
Consumer	Health & Safety Feedback Mechanism Consumer Privacy Transparency End of life responsibility
Local Community	Access to material resources Access to immaterial resources Delocalization and Migration Cultural Heritage Safe & healthy living conditions Respect of indigenous rights Community engagement Local employment Secure living conditions
Society	Public commitments to sustainability issues Contribution to economic development Prevention & mitigation of armed conflict Technology development Corruption
Value chain actors (not including consumers)	Fair competition Promoting social responsibility Supplier relationships Respect of intellectual property rights

Impact assessment is performed by classifying and characterising inventories into impact categories. in SLCA impact categories are human rights, working conditions, health and safety, cultural heritage, governance, and socio-economic repercussions. The exact relationships and characterisation models between stakeholders and impact categories are not clarified in the guidelines, nor is it the case for subcategories and impact categories (Sala et al., 2015). The generic assessment system from categories to inventory data is illustrated in figure 5-4.

SLCA can be carried out on two different levels: generic product chain on a general level or actual product chain of specific product. Generic assessments are often carried out to identify social hotspots, which can be used to highlight potential risks of significant negative social impacts and risks to brand reputation as well as identification of opportunities for social improvement (Benoit-Norris et al., 2012). One can interpret a generic assessment as a top down approach where data are collected from regional, national, and industrial sector levels. Whereas, specific product chain assessment aim to collect data from actual product level, if not product group level. There is only one available database for SLCA, namely the Social Hotspot Database (SHDB) (Benoît-Norris et al., 2011). SHDB mainly contains social data for hotspot assessments on country level and sector level. Only product group data are available for 57 predefined sectors, as data is difficult to obtain at product level.

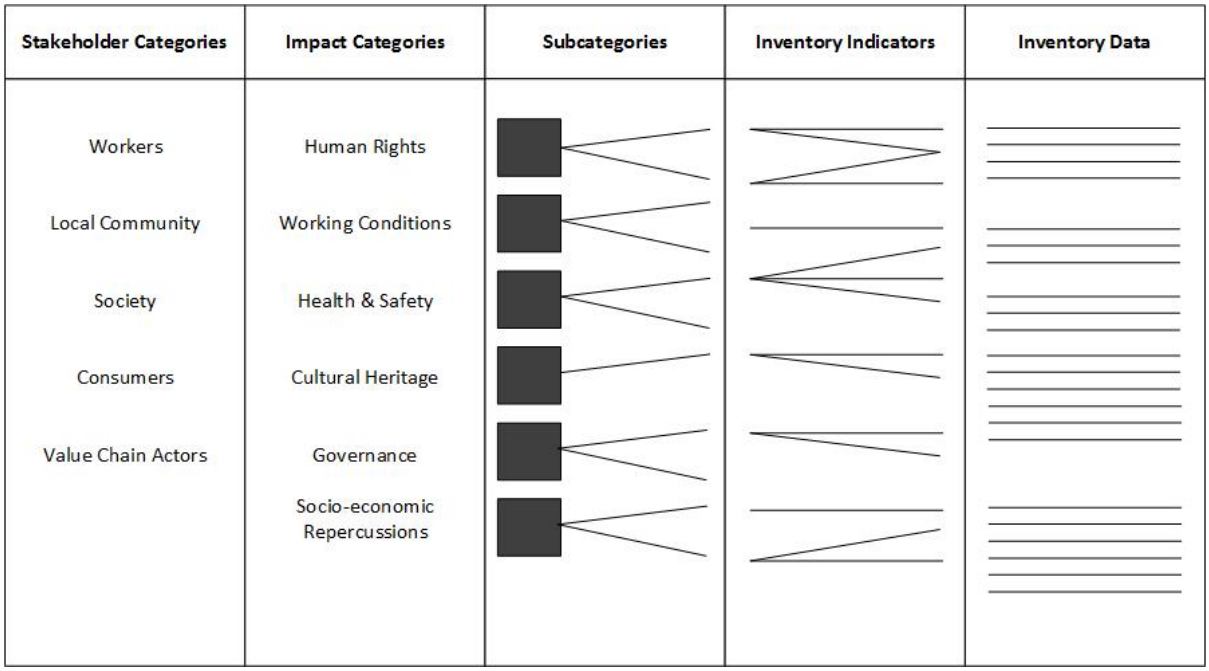

Figure 5-4 Generic assessment system of SLCA impact assessment

5.3.2.1 Two Approaches of Impact Assessment

SLCA seeks to assess the potential or real social impacts of a product or service (Chhipi-shrestha et al., 2015). Social impacts are defined as the impacts on human capital, human well-being, cultural heritage, and social behaviour. Currently, there are two main schools of thought in SLCA research and practice, namely performance reference point method and impact pathway method.

Type 1: Performance reference point method mainly focus on living and working conditions of workers, centring on issues such as forced labour, child labour, discrimination and freedom of association or collective bargaining along the life cycle phases (Chhipi-shrestha et al., 2015). The reference points are usually based on internationally accepted minimum performance levels like the International labour organisation conventions, the ISO 26000 guidelines on social responsibility, and OECD Guidelines for Multinational Enterprises (ISO, 2010; Parent et al., 2010). This method does not assume a causal relationship between processes and the abovementioned conditions, but rather the empirical correlation between the two. This method typically utilises scoring system for the impact subcategories and scoring aggregations for the final stakeholder category score or impact category score. This is illustrated in Figure 5-5. The scoring methods can be two levels (e.g. yes or no, or 1 or 0) (Aparcana and Salhofer, 2013; Foolmaun and Ramjeeawon, 2013) or multi-level (Ciroth and Franze, 2011; Dreyer et al., 2006, 2010; Ekener-Petersen and Finnveden, 2013; Hutchins and Sutherland, 2008) However, the utilisation of subcategories can raise questions regarding whether the subcategories are positive or negative in nature. Studies can sometimes be criticised to be based on authors' "own thoughts" (Wu et al., 2014).

On the other hand, Type 2: impact pathway method assesses the social impacts of products or services. It utilises impact pathways as characterisation models that consists of midpoint and endpoint indicators like ELCA (Parent et al., 2010). Although some characterisation models have bypassed midpoint categories altogether (Figure 5-5). This method is based upon the causal relationship between processes, for example the relationship between toxic emissions and its consequences on human well-being. There are two typical characterisation frameworks for the impact pathway method: single impact pathway that measures a single social issue, and multiple impact pathways. Past case studies with single impact pathway focused on AoP of human (Feschet et al., 2013; Hutchins and Sutherland, 2008; Norris, 2006).

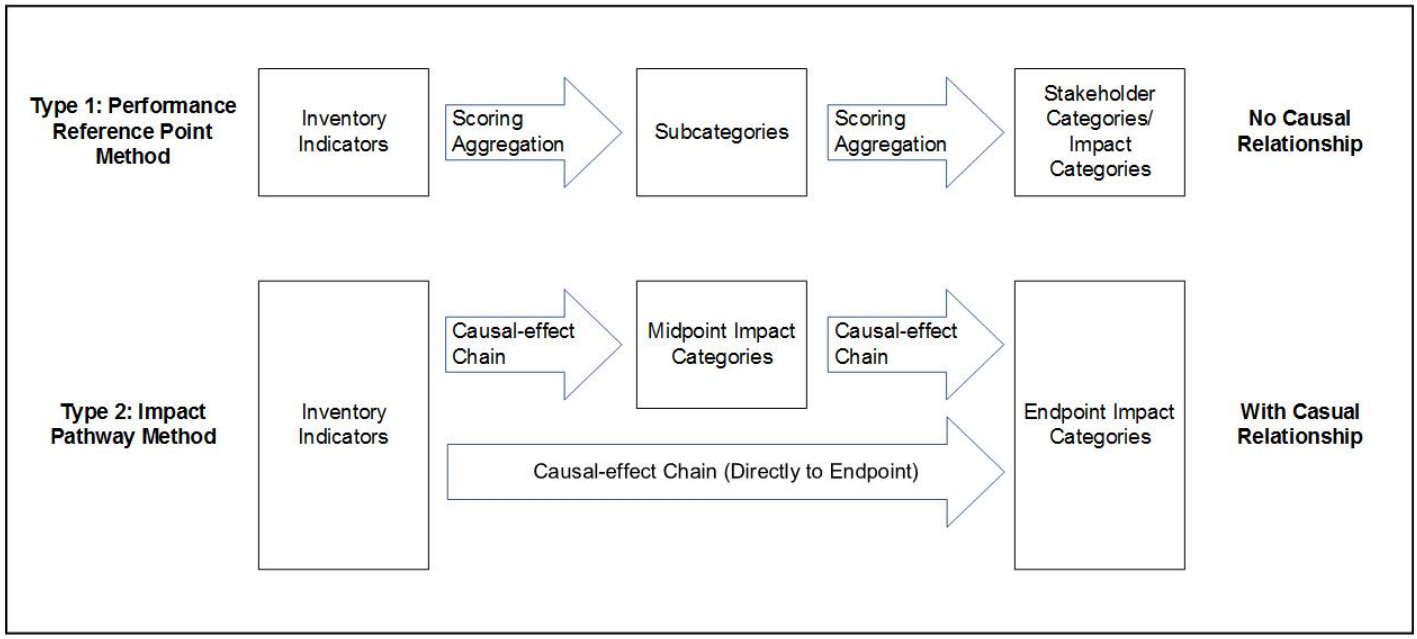

Figure 5-5 Two methods of impact assessment in SLCA (Wu,2014)

They established the causal relationships between national health improvement (e.g. life expectancy or infant mortality) and economic growth (e.g. GDP).

Petti et al., (2014) identified 35 publications where SLCA case studies were performed. Of those 35 publications, 68% carried out the case study by using the reference point method, while 6 % implemented the impact pathway method. This does not necessarily equate to the reference point method being better, but rather the impact pathway method is difficult to classify the impact pathways and collect relevant, specific date of a product. it was concluded that the reference point method measures the overall social performance which relates to the relative importance of each context unit over the entire product system (Parent et al., 2010). Whereas the impact pathway method measures the social impacts of specific products which relates to the functional unit stated in assessment.

5.3.3 Positive Impacts Consideration in SLCA

A key assertion of this research is the need to assess the positive impacts of products throughout their life cycles. However, there is little consensus on the definition of positive impacts and on methods that incorporate them into impact assessments (Shin et al., 2015). To a certain extent, the development in social life cycle assessment (SLCA) embodies the evaluation of positive impacts. In comparison to its ELCA predecessor, which largely considers only negative

impacts, SLCA also includes positive impacts relating to social factors (Ekener et al., 2016). However, these positive impacts are sometimes simply the absence of a negative one. For example, a factory's strategy of not using child labour is considered to be a positive impact, whereas in reality, the elimination or reduction of child labour is really only achieving a neutral or reduced negative impact. While the concept of positive impacts has arisen in recent years, there is still no shared definition of positive social impacts (Sala et al., 2015).

SLCA guideline defines positive impact as impacts that go beyond compliance specified by laws, international agreements and certification standards. This indicates that social benefits/social security issues are only considered positive only under the assumption that they provide additional benefits to the stakeholders. To be precise, this means benefits above the level expected and already given in society. Therefore, positive impacts should cause a "net gain" in human well-being. Furthermore, similar to ELCA, which SLCA inherited, majority of the researches in SLCA so far mainly focuses on negative impacts or generic hotspot assessment on potential negative impacts. Thence, there are no consensus, well-developed, clear definition of positive impacts and methods that truly incorporate these into impact assessment.

Various ways of addressing positive impacts are identified from reviews of literature. Ekener-Petersen & Finnveden (2013) inverted the issue by measuring the lack of/ low level of positive aspects as negative impacts. However, this approach has limitation in identifying positive impacts. Benoît & Mazijn (2009) expanded this approach by setting performance target points that the impacts are assessed against, thus positive and negative impacts can be determined from the performance target points. Ramirez, Petti, Brones, & Ugaya (2014) also adopted this approach, however positive and negative impacts were not distinguished.

A second approach is use by Ciroth & Franze (2011), where negative and positive impacts are rated by assigning values from 1 to 6, (1 for positive and 6 for very negative impacts). This approach is easy to use; however, there are arguable elements such as assessing the lack of forced labour as a positive aspect, whilst this merely put it back to neutral impacts at best. Another approach to address positive impacts is the theory of hand printing, proposed by Norris (2013). Hand printing attempts to measure the positive impacts in terms of avoided negative environment impacts that would have contributed to the environment footprint. While the activities discussed in hand printing involves interactions between individuals and social groups, the fundamental theory is still environmentally linked.

Ekener et al. (2016) divides the subcategories in the SLCA guidelines into positive and negative impacts, and suggested tentative indicators for the 12 positive social impacts that were identified. However, there is no proposed way to identify, measure, and assess the beneficial user values. While life cycle approach should assess the entire life cycle of products, it can be argued that societal benefits (user values) are the most important social impacts as they characterise the products and fulfil the needs of products. To put it simply, all the other positive or negative impacts should not be made if the products are not fulfilling a need, thus should not be manufactured in first place. Therefore, it is important to assess the benefits of products in particularly during their use phase.

5.4 Play Benefits & Evaluation of Play/Toys

The way that toys are marketed were discussed in previous chapters, this section of the review is going to present the beneficial values of playing, and how toys are evaluated on their ability to afford this activity. In order to understand the benefits of playing, it is important to understand what "play" is and how different types of play can bring about different benefits.

5.4.1 The Definition of Play

Due to its complexity, it is generally agreed that defining play is difficult and challenging. Play is an abstract concept and have several elements for every aspect of child development (Moyles, 1989). There were various attempted to define play for different purposes, but perhaps the most comprehensive and extensive definition is provided by Kudrowitz & Wallace (2010). They summarised previous definitions and defined "play" as "*the quality of mind during enjoyable, captivating, intrinsically motivated and process focused activities*." Table 5-2 shows all the elements of play summed up by Kudrowitz and Wallace, Huizinga, and Caillois (Caillois, 1962; Huizinga, 1950; Kudrowitz and Wallace, 2010). it is worth noting that the process-focused nature of play is highlighted by all three, a notion which is echoed by Pellegrini (2009) who concluded that play contexts free partaking individuals to focus on the "means" as opposed to the "ends". One can argue that the presence of rules, space/time boundaries, social groups, and uncertain outcomes are not essential to all play activities, thus should be considered in the distinction of types of play.

5.4.2 Play Classification

Play classification can often be mixed up with the definition, after all, play is a vague and complex subject. In the market, it is often related to the different categories of toys, as

mentioned in previous chapter. However, the vast number of categories do not necessarily represent the types of plays that these toys afford. There are a few published play classifications for different use in the play research community and toy industry. However, some of these definitions are not necessarily fit for assessing the benefits and informing design team. Some of these definitions can have overlapping elements (e.g. make believe play and storytelling play), while others are too specific.

Table 5-3 lists out classifications summed up by seven authors, it showed some overlapping areas of classification and how classifications can be different because of differing perspective. For instance, Caillois (1962) classifications mainly focus on games rather than playing with toys. Del Vecchio, (2003) classifications may be too detailed as it was developed into a graphical tool, and it is not applicable for general use. Goodson and Bronson (1997) classified plays in the perspective of products safety, this is not unlike the toy market's classification of different categories of toys. Other classifications focus on the benefits that different types of play can potentially bring. However, the relationships between benefits and types of play are quite complex to try to trace back from the benefits that different types of play afford.

Table 5-2 Elements of play

Elements of play		
Kudrowitz and Wallace (2010)	***Huizinga (1950)***	***Caillois (1962)***
Enjoyable	Fun element	–
Captivating	Utterly absorbing	–
Intrinsically motivated	Voluntary	Free
Process-focused	No profit	Unproductive
Element of pretence	Outside ordinary life	Make-believe
Based on rules	Rule based	Governed by rules
Space/time bounded	Boundaries of time, space	Separate
Social groups	Creates social groups	–
Uncertain outcomes	–	Uncertain

Table 5-3 Play classifications

National Institute for Play (2006)	***Goudson & Branson (The Consumer Product Safety Commission, 1997)***	***Gene Del Vechio (The Blockbuster Toy, 2003)***	***Roger Caillois (Man, Play and Games et al. 1962)***
Imaginative/ Pretend play Creative play Story telling play Social play Body play Object play Attunement play	Make believe play Manipulative play Creative play Active play Learning Play	Emulation play (make believe) Master / Story telling play Creation play Friend play Experience play Collection play Nurturing play	Ilinx (perception disruption) Mimicry (pretend) Agon (competition) Ales (chance)
Whitebread (importance of Play, 2012)	***Goldstein 2012***	***Kudrowitz and Wallace (2010)***	
Symbolic Play Games with rules Social-dramatic play Physical play Play with objects	Exploratory play Mastery play Social play Pretend play	Sensory play Fantasy play Construction play Challenge play	

Kudrowitz and Wallace (2010) provided one of the most well-rounded classification of play. Their design tool proposed a four-nodes play pyramid that consist of sensory, fantasy, challenge, and construction. These four classifications of play and the activities involved coincide with Piaget's stages of cognitive development associated with young children development. The stages are summarised as follow (Bee and Boyd, 2012):

- Sensory-motor stage (0–18 months old) – where children engage in sensory focused play which also includes moving objects to produce reactions.
- Preoperational stage (18 months–6 years old) – where children engage in symbolic play when the child can perceive and imagine.
- Concrete operation stage (6–12) – where children engage in more problem-solving play. Play will involve the idea of classification and regulations.
- Formal operations stage (12–15) – at this stage of development, children's thought and play become more abstract. Play becomes more social and refined.

Kudrowitz and Wallace (2010) proposed sensory play and fantasy play matches directly with Piaget's stages, while the challenge play and construction roughly correspond to concrete operation and formal operation stages. Furthermore, the authors proposed five play characteristics that toy products afford: play involvement, social involvement, level of restraint, mental vs physical play, and gender distinction. Play involvement refers to whether the toy user is an active participant or a spectator. Social involvement refers to the level of interaction between the user and other people, it can be solitary, parallel, associative, and cooperative/competition (Parten, 1933). Level of restraint is concerned with the number of rules, it ranges from completely free to having straight rules like in a football game. Mental and physical play are self-explanatory, toys and games can require mental and physical skills simultaneously (e.g. ball games like basketball and football require both physical athleticism and mental tactical minds).

Gender distinction in toys is something that is much argued amongst toy marketing, retailing, and parenting circles. Kudrowitz and Wallace (2010) mapped out the target age of toys to Blakemore and Centers, (2005) studies in gender perceptions of toys, and observed that gender perceptions tend to begin when toys start to accommodate for children's fantasy play and will merge back together once toys become more abstract and involve more challenge play. This is depicted in figure 5-5. There are several works in this research area, children as young as 8 months old may already show preference for sex-typed toys (Cherney and Dempsey, 2010;

Todd et al., 2016; Zammuner, 1987). Some points to parental behaviour and cultural traditions as an influencing factor (Garvey, 1990; Rheingold and Cook, 1975). Yet a larger number of researchers concluded that preference for sex-typed toys are more to do with their innate preferences for certain purpose and features of toys (Alexander and Charles, 2009; Alexander and Hines, 2002; Benenson et al., 2011). However, colours and shapes do not seem to influence children's preference (Jadva et al., 2010). This indicates that there seems to be a contextual preference for the types of toys that children of different gender prefer, but this influence is further coupled by cultural traditions and marketing strategies. These ideas are noticed, but this issue is outside of the research boundary of this particular project.

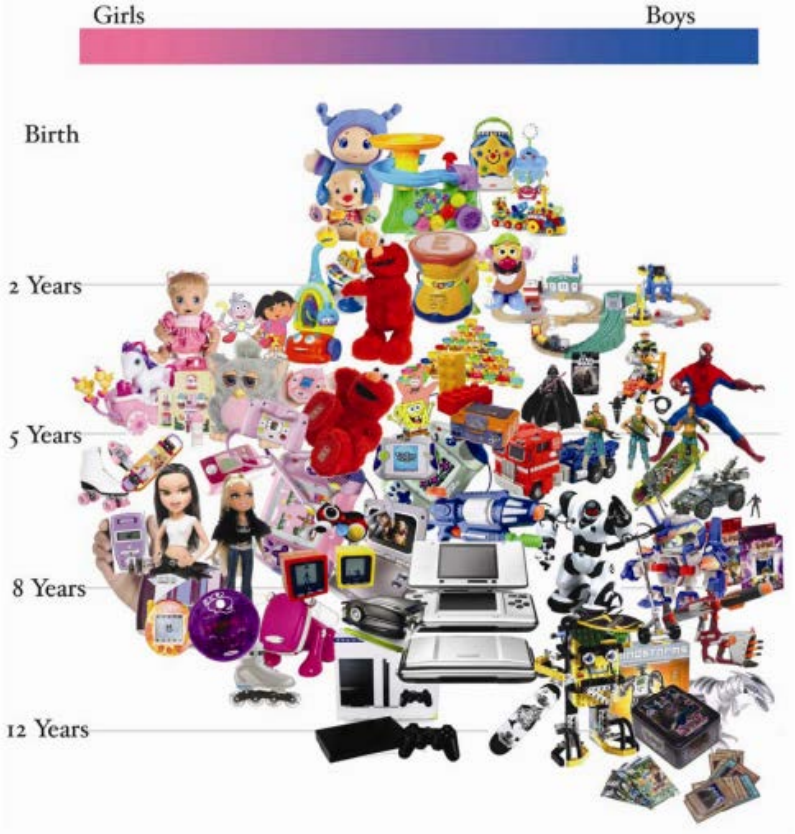

Figure 5-6 Gender perception and intended age of toys (adapted from Kudrowitz and Wallace, 2010)

5.4.3 Play Benefits

Many researches pointed out that play deprivation has various detrimental effects on children's development. A number of researches revealed that the lack of play is believed to impaired brain region development, flexibility, and deficient growth in brain functioning (Chugani et al., 2001; Else, 2009; Gray, 2011). General problem-solving skills, emotional well-being, and self-control are also believed to be affected. It also links to problem in social functioning skills (Fearn and Howard, 2012; Taneja et al., 2002; Valentino et al., 2011). Others even linked play deprivation and decline of free play to mental health issues with children such as anxiety and depression (Chudakoff, 2007). Yet some even suggest that the likelihood of criminally violence may increase in mature years because of the lack of free play (Brown, 1998). Given that the lack of play can have such effects on children's development, it is only logical to deduce that playing has benefits. Play benefit is a subject that has been studied for an extended time. Table 5-4 are summarised from two major review reports and a major online qualitative toy reviews (Fundamentally Children, 2017; Goldstein, 2012; Gummer, 2015; Whitebread, 2012).

Six main categories of play benefits are summarised: creativity, social behaviour, communication, cognitive development, physical skills, and emotional well-being. Creativity is mostly encouraged through free play. Social behaviour refers to the ability to interact with other people, where it would be helpful in later life in cooperating with others. Communication is summarised into two set of skills; language and linguistic skills, and other representation skills, such as numeric and symbolic representations. Cognitive development can be broken down into basic understanding of the physical worlds and more abstract thoughts. Physical skill refers to gross muscle development that require strength and balance and fine motor skills that require finger dexterity and steady control. Emotional well-being refers to peace affordance which gives peace of mind. Parent attunement is the bond that parents share with children which also help the emotion development of children. Meta-cognitive development is the development of self-awareness and self-control. Different types of play are related to multiple play benefits, in general experts recommend a mixed variety of a "play diet". However, there are currently little research effort to establish the relationship of play types o play benefits that goes beyond correlation relationship. In other words, how much of certain type of play is going to result in a certain amount of benefits.

5.5 Chapter Summary

This chapter reviewed the social consideration within sustainable design and assessment tools. The concept of positive and negative impacts was introduced, this idea was further discussed in “use phase” consideration, and the importance of such considerations was highlighted. SLCA’s historical development was described, its method was expounded and the two impact assessment methods were explained. Reviews on researches in positive impacts in SLCA were carried out, it was discovered that there is no consensual definition in positive impacts, and methods to assess them varied. Finally, the chapter described the benefits of playing with toys. It began with presentation of previous researchers’ definition of play. The classification of different types of play was described, and the benefits from play were summarised.

Table 5-4 Play benefit classification

Play Benefits	**Whitebread 2012**	**Goldstein 2012**	**Gummer 2015/ Good toy guide**
Creativity	▪ Creativity	▪ Creativity	▪ Creative development
Social Behaviour	▪ Social interaction ▪ Cooperative skill	▪ Increases empathy, compassion, and sharing ▪ Models relationships based on inclusion rather than exclusion	▪ Social development
Communication ▪ Linguistic & Language ▪ Other Representational Abilities	▪ Development of language, narrative skill ▪ Representational ability ▪ Numeric expression	▪ Improves nonverbal skills ▪ Reading and speaking skills ▪ Using symbol ▪ Development of language	▪ Speaking skill ▪ Listening skill ▪ Reading skill ▪ Writing skill
Cognitive Development ▪ Logical/Critical Thinking ▪ Basic Physics/Mechanism	▪ Problem solving, reasoning skill ▪ Cognitive development ▪ Abstract thoughts formulation ▪ Concentration & perseverance ▪ Memory	▪ Increases attention and attachment ▪ Mathematics ▪ Memory	▪ Memory ▪ Attention ▪ Logical thinking
Physical Skill ▪ Fine Motor Movement ▪ Gross Motor Exercise	▪ Hand-eye coordination ▪ Active exercise, strength and endurance ▪ Fine-motor practice	▪ increase the efficiency of immune, endocrine, and cardiovascular systems ▪ Decreases fatigue, injury ▪ Increases range of motion, agility, coordination, balance, flexibility, and fine and gross motor exploration	▪ Muscle development ▪ Fine motor ▪ Gross motor
Emotional Well-being ▪ Parent Attunement ▪ Meta-cognitive development (self-awareness) ▪ Peace Affordance	▪ Emotional development ▪ Emotional well-being ▪ Meta-cognitive development, self-regulation ▪ Positive attitude towards challenge ▪ Emotion understanding	▪ Reduces fear, anxiety, stress, irritability ▪ Creates joy, intimacy, self-esteem ▪ Improves emotional flexibility and openness ▪ Increases calmness, resilience, adaptability and ability to deal with surprise and change ▪ Play can heal emotional pain.	▪ Personal and emotional well-being ▪ Self-identity

Chapter 6 Research Methodology

6.1 Introduction

This chapter describe the research methodology used to undertake the research reported in this thesis, which follows the well-established, four-stage approach widely adopted for research programs. It begins with a brief description of the definition of research which is followed by a summary of the objectives of this research and how the research methodology stages address these objectives. A more detailed description of each of these four stages is then provided, which include: a review of relevant literature together with the subsequent refinement of the research assertion; the development of a framework for incorporating societal benefits; the development of an societal benefits assessment methodology; the development of a prototype sustainable design support tool and its associated case studies; and finally the analysis and discussion of results leading to the development of the research conclusion.

6.2 Overview of Research Methods Categories

Research is a systematic investigation into the study of materials and sources in order to establish facts and reach new conclusions. It is summarised as a structured inquiry that utilises established scientific methodology for problem solving and generating new knowledge (Grinnell and Unrau, 2005). There are a number of different definitions and categorisations of research methodologies, these definitions span across several academic disciplines such as environmental sciences, social sciences, management, engineering etc. Kumar (2005) classified research into three main focuses (Figure 6-1): research application, research objectives and research inquiry.

With regard to application, two categories can be distinguished – pure and applied research; most of the pure researches are abstract in nature, whereas applied researches aim to solve practical problems (Kumar, 2011). Six key objectives can be defined and characterised for research activities: Descriptive, Exploratory, correlational, explanatory, predictive, and action research.

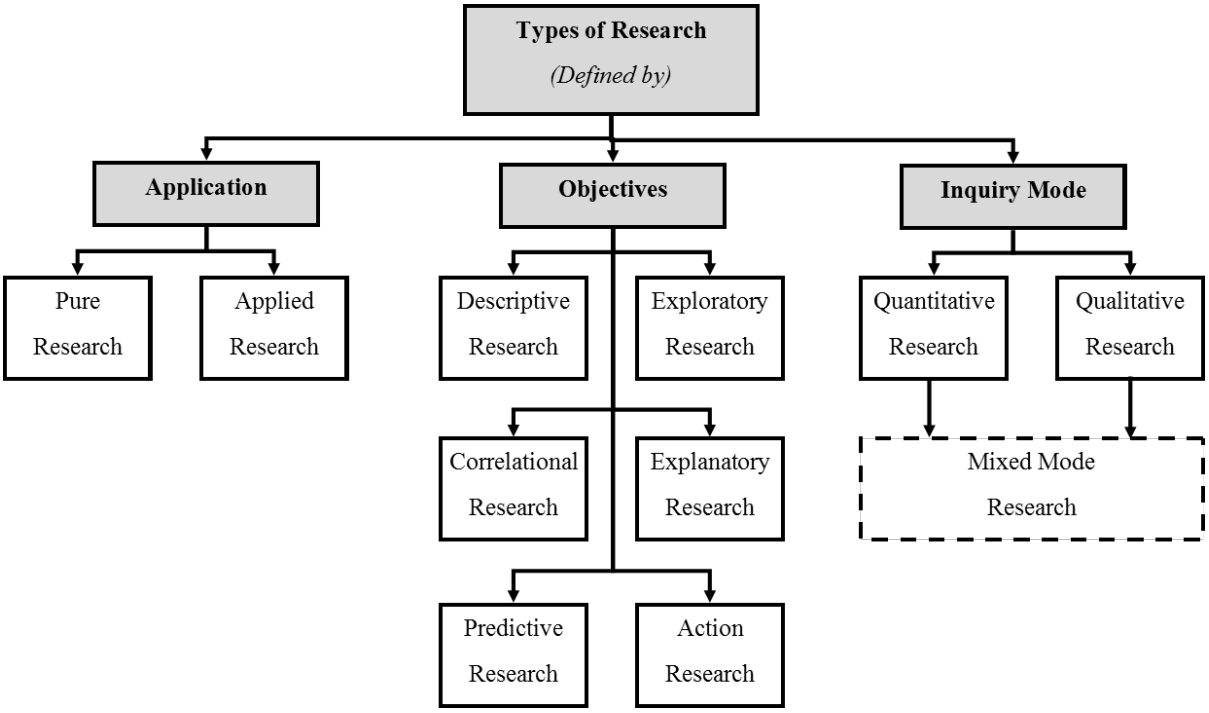

Figure 6-1 Types of research (Kumar, 2005)

- Descriptive research aims to describe the characteristics of a certain phenomenon or situation. It does not, however, describe the causal reasoning of the methods.
- Exploratory research aims to investigate and discover the reasons.
- Correlational research intends to make certain of relationships between two phenomena that was hypotheses.
- Explanatory research attempts to rationalise why relationships exists and how it is formed.
- Predictive research takes a number of variables and seek to forecast an outcome.
- Action research surveys and inform practice (Kumar, 2011; Wisker, 2008).

Lastly, in terms of the inquiry mode, the process by which answers are discovered to the research question, there are two common categories: quantitative or qualitative (Cohen et al., 2011). Quantitative research involves recording measurements of variables and accumulating vast amount of significant data. The research normally follows a predetermined proposal and is mostly utilised to measure the extent of an issue or phenomenon. This is normally referred as a structured approach as opposed to a qualitative research methodology, which is more suitable for exploring the nature of a particular issue or phenomenon and is described as an unstructured approach. This methodology grants flexibility in research activities but is more subjective. There are advantages and disadvantages in both

methodologies, and inquiry mode can be mixed and implemented to suit the needs of a particular research project. The applied research adopted for this thesis follows a mixed of quantitative and qualitative modes and has explanatory goals and has action research in practice which are described in more detail in section 6.3 below.

6.3 Thesis Research Methodology

For this thesis, the research adopted an action research approach. Action research aims to survey and improve the practices undertaken by the "actors" of the studied activities. For this research, the actor is identified as the toy industry and the activities are business strategy decision making and product design management. Generally, this mode of research can be structured in four phases; plan, act, observe, and reflect. It is expected that upon reflection, improvement can be planned and implemented, thus this research method is iterative and promotes continuous improvement. The four-phase structure of action research also correspond to a conventional four stages approach as described by (Greenfield, 1996)).

The research began with the definition of research hypothesis and the refinement of this particular hypothesis into specific aims and objectives. The second stage was theoretical research in which frameworks, tools, and methods were developed. The first and second stages formed the planning part of action research where current practices are reviewed and methods are planned and developed for improvement. The third stage was the testing and validation of theoretical research using case studies. This stage was the acting part of action research in which the methods and tools developed during planning were implemented in case studies. The fourth and last stage was the analysis of research results, this formed the reflection phase of action research where results from case studies were used to inform researcher for improvement in methods and practices. These stages of research methodology applied in this research are illustrated in Figure 6-2. The research assertion and hypothesis were originally defined based on the author's prior knowledge and experience of the toy industry, which was built up during a short period as market researcher for a Hong Kong based toy manufacturer and factory visits. The knowledge was then further widened by conducting extensive literature reviews of relevant industrial and academic publications in the areas of the toy industry, SPD, and social sustainability assessment. The final review of social sustainable assessment methods and the research in toy beneficial values to child development had particular influence on both the refinement process and in directing the second stage of research regarding the novel assessment framework and tool development and refinement.

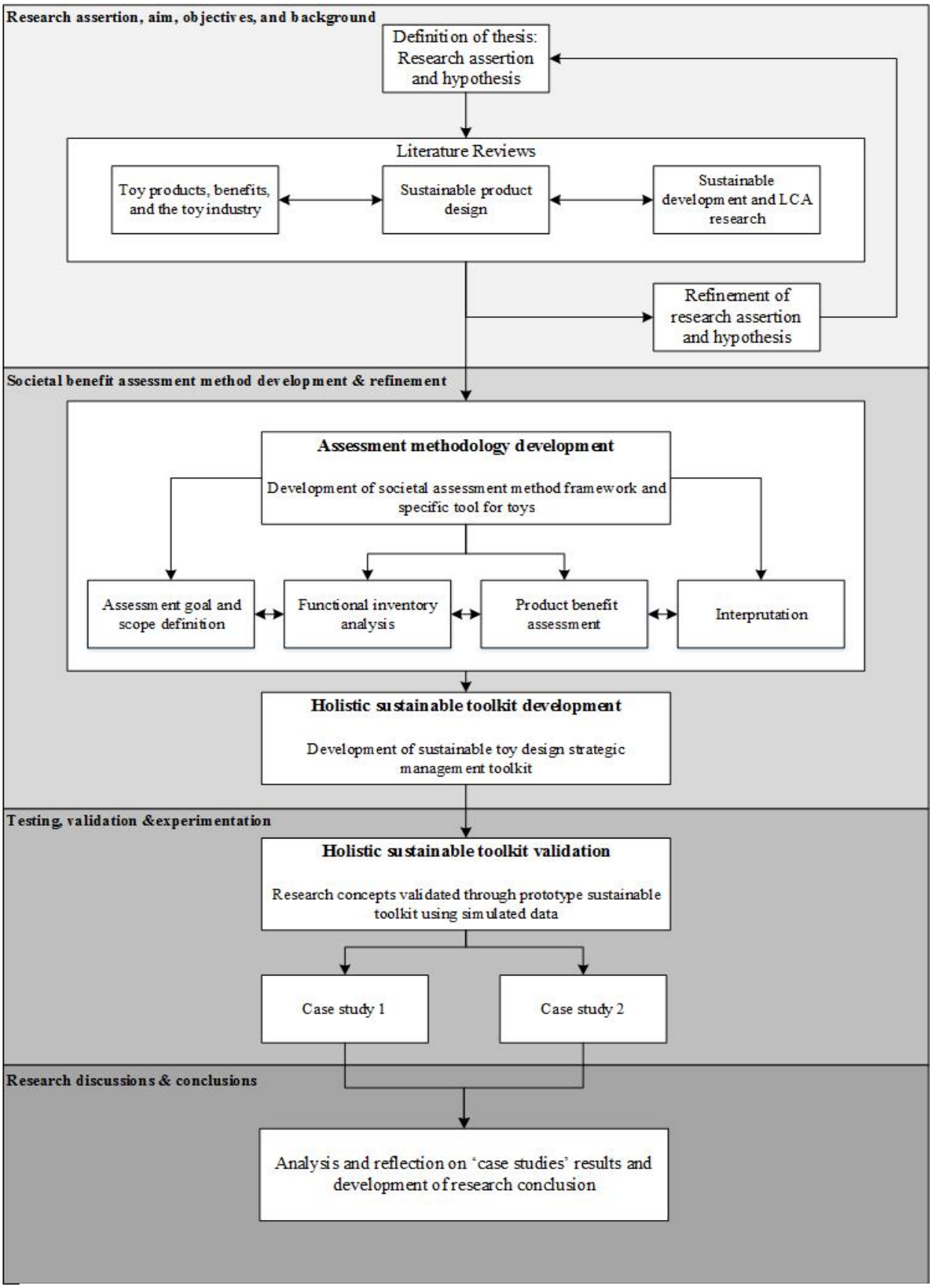

Figure 6-2 Research Methodology used within the Thesis

Explorative and explanatory research approaches were applied for the literature reviews. The objective of the reviews was to investigate current practices in sustainable product design, in particularly positive social factors consideration. It also aimed to explain the relationship between toys' functions and the benefits from playing with them, as this relationship is mostly studied through correlational and qualitative approach.

An initial framework for the assessment tool was planned and developed from the knowledge and understanding gained from the first stage of research methodology and the brief working experience of the author in the toy industry. Action research method is particularly suitable at this stage, as the research undertaken is collaborative and participative; unstructured discussions were had with industrial contacts working in toy assessments for parental buying guides. The framework and the subsequent toolkit that were developed had undergone several iterations as a result of these discussions and feedbacks.

In addition to the guidance obtained from the review of existing SD tools and assessments, these discussions also provided clear support for the novelty of the proposed assessment framework and tool by identifying existing gaps in knowledge. The inquiry mode at this stage is a mixture of qualitative and quantitative research, as it aims to convert correlational qualitative societal benefits knowledge into measurable data that can inform and aid businesses' sustainable decision making. It was intended that the framework would provide a stepwise approach structure to identify required knowledge to build an assessment tool. In addition to the concepts of positive social value assessment of products, a toolkit is also developed to demonstrate how this may fit into a current sustainable practices and aid strategic product management and design for manufacturers.

The third stage of the research involved the initial validation of the assessment tool and the integration of the tool into the sustainable toolkit using simulated and real-world data for two case studies. The case studies were selected to demonstrate two typical scenarios in the toy industry; the first assessing product of a SME toy manufacturers that has a small targeted market and the second a global manufacturer with worldwide reach. Within each case study distinct aspects of the toolkit were tested, and outcomes recorded to inform further development of the assessment tool and integrated toolkit.

The final stage of the research methodology is to analyse the findings from case studies, and, in the context of all research results documented in the thesis, to draw overall conclusions

and form further areas of research. Although the methodology presented in this chapter may suggest a linear progression through the clearly defined four stages in this section, in practice, various aspects of this study was revisited and redeveloped in light of new knowledge and findings as the research progressed.

6.4 Summary

This chapter identified various characteristics of research utilised in the thesis, based on the requirement to address the research aim and objectives identifies in Chapter 2. The research methodology adopted in this thesis has been presented. The four stages of research methodology were illustrated schematically, showing the chronological development of the thesis. The research supported by the first stage of the methodology is reported in the earlier chapters of the thesis, namely Chapters 2 – 5. The following thesis documented the research findings supported by stage two, three, and four of the research methodology.

Chapter 7 Framework for Societal Benefit Assessment

7.1 Introduction

This chapter presents a framework for assessing positive social impacts of product to the customers during the product's use phase. This forms the first of three research chapters describing the research activities undertaken in this thesis. This chapter begins with a definition of societal benefit, and a description of what the term encompasses. The second part of the chapter describes the development of the societal benefit assessment framework and how it relates to previous 'environmental and social' assessment research and frameworks, in particular LCA. The final part of the chapter describes the structure of the societal benefit assessment framework and the process and data that are required for such assessment and compares this to the IS014040 LCA framework to highlight its key differences and demonstrate the novelty of this research.

7.2 Definition of Societal Benefit

It was established from the review in chapter 5 that current sustainable product design practices lack the consideration of positive social impacts, particularly in relation to the product's functionality during use. While research in positive impacts assessment has arisen in recent years, particularly in SLCA, there was little evidence to suggest that there is a homogeneous definition on positive social impacts within the research field. Past attempts to define and measure these have been limited to the resource, manufacture and disposal life cycle stages, whilst the use phase has been largely ignored in terms of positive impact assessment. This research attempts to address this gap of knowledge by developing a framework and design decision support tool for positive social impact assessment.

Firstly, it is important to define positive social impacts for the development of this framework and design decision support tool. The positive social impact of product is defined in this thesis as the societal benefits of a product. The word 'societal' is used instead of 'social', as this research aim to investigate the impacts of products relating to the society, rather than situations that depend on individuals involved in society. The word 'benefit' is used to embody

the inherent positive aspects and to differentiate from the word ‘impact’ which would require explanation as to whether it is positive or negative. The societal benefits of a product are regarded as the benefits that the product brings to society, or its collective users, during its use. Specifically this will focus on the intended benefits resulting directly from the product’s various functionalities. While the greater supply networks of the product’s lifecycle may bring about benefits, it should be argued that those are not direct benefits to society. The most benefits that a product can afford its users and greater society is arguably from its functions, after all, why should valuable resources be committed to manufacture a product that does not effectively benefit society? Regardless of the good environmental practices that may or may not be present and the employment opportunities that it brings about.

7.3 Framework Development

A framework is required to provide a systematic approach towards understanding and assessing the societal benefits of products. In doing so this will ensure replicability of the process and comparisons to be made from different studies that follow the same step-wise approach. Three key factors have been identified as being essential considerations of this framework:

1. Intended users of the product

2. The functions of the product

3. The benefits relating to those functions

Firstly, it is understood that society is not a homogenous collection of like individuals but instead is highly diverse with various social groups with various intersecting memberships. Some groups within a selective range are exclusive, such as age, where an individual can only belong to one group at a time. In other examples groups may be more open to multiple affiliations such as occupation where an individual may have multiple jobs. It is also clear that it would be unethical and divisive to justify the needs of one collective society group over another. One approach to overcoming this dilemma would be to establish a boundary around the societal group to be assessed. This would provide focus for the assessment to consider only those factors relating directly to the needs of that group that are being met. Furthermore, the assessment relates primarily to the user benefits of the products intended functions rather than unintended ones. A wooden chair could be burnt for warmth but that is not its intended purpose.

The essence of societal benefits is how the designed functionality benefits the collective users. Therefore, the other two key factors for an assessment is the functionalities of the product assessed. It is crucial that all intended functions of the products should be captured, in order to truly reflect the product and to gain a thorough understanding of the relationship between functions and benefits. For the same reason, it is as crucial to encapsulate all the potential benefits of the products.

7.3.1 Scope of Framework.

Before describing the details of each phases of the framework, the scope of the framework must be defined. This is not to be confused with the scope of the assessment from the goal and scope phase. This section intends to describe the context of the framework rather than setting up an assessment. The scope of this research focuses mainly on the three key factors mentioned earlier: intended users of the product, the functions of the product, and the benefits brought about by using the products. However, there are other factors related to the context of societal benefit that are not included in the scope of this framework. There are four factors that fall outside of the scope of this assessment framework: secondary users and other people affected, unintended and non-designed functions, negative effects, and unrelated benefits. The following section will define these factors and explain their omissions from the framework.

The framework does not concern other people that are affected by the product. For example, a toy can be used as a teaching aid by a teacher who is delivering a lesson to a class of pupils. The framework is designed to assess the direct relationship between users, products, and benefits only, it does not accommodate for secondary users. Unintended functions and misuse are not part of the scope of this framework, this was explained earlier. Negative effects and unrelated benefits also do not form part of the assessment considerations. Negative effects are the effects that directly harm the users or other people around. Whilst it is acknowledged that this factor is important, it was the intention that this assessment framework will be integrated with SLCA in further development and SLCA has covered negative effects sufficiently with its health and safety impact category and other similar impact categories. Unrelated benefits can be divided into two groups: socio-environmental impacts and socio-economic impacts. Socio-environmental impacts may refer to the cultural settings around the users. The framework does not take into account of whether the products can improve the social and cultural settings of the users. Products are designed to provide functions to a design specification and generally are not designed to improve the social-environment. Socio-

economic may refer to the affordability of the product, which is outside of the consideration of the assessment framework. It was regarded as a factor that should be considered in design process rather than SBA. Any future financial gain is also outside of the scope of consideration, as the framework focuses in functions rather than resale values.

7.3.2 Justification for LCA Framework Adaptation

Several sustainable product design methods were highlighted to be potentially adapted for the SBA framework base on the three key factors that were identified. The ISO 14040 LCA framework, hereby referred as LCA framework, was identified as having the greatest potential for adaption, other methods such as Value Engineering method, and QFD used widely by engineers during the product design process, were also considered but were found to be less transferable to this problem. Value Engineering has the potential to capture customer's perceived value of separate components of products in financial terms, the method offers through review of products into components and their related function, however it does not relate these functions into benefits, instead presenting in monetary form. QFD is normally used to ensure all customer needs are capture and transferred into technical design details. While this method can identify the relationships between design features and customer needs, these do not necessarily translate into societal benefits.

The LCA framework was selected as a foundation for the initial development of the new societal benefits assessment (SBA) framework for its iterative nature and the transparent approach. The phases of the LCA framework can effectively encapsulate the three key factors highlighted earlier. LCA consists of four phases; goal and scope phase, inventory analysis, impact assessment, and interpretation. The goal and scope phase is used to set the assessment boundary and restrict the societal group, inventory phase can catalogue the functions of product, the impact assessment phase can identify the societal benefits of the products, classify and characterise the relationship between functions and societal benefits. The following sections describes how the first three phrases of the LCA framework is adapted to measure the three key considerations in SBA.

7.3.3 Goals and Scope

As its name suggests, the goal and scope phase describes the purpose of the assessment, it sets the boundary and scope, and identified the required data and method for other phases of the assessment. Similar to LCA, this phrase of SBA will make decisions that would determine a working plan for the rest of the assessment. It will identify the intended users of the product

assessed, set boundary for the assessment, and define methods for the following phrases. Goal and scope phase is an iterative process and can be revisited throughout a SBA in light of any new information or situation where there is a lack of information.

7.3.3.1 Functional unit

One of the key aspect of LCA is the use if functional unit. Functional unit in LCA ensures fair comparisons of products as long as they fulfil the same functional statement defined. For example, a container that can be reused to carry 100mL of water every day for a year. This would allow a water bottle, a cup and a plastic bag that can contain water to be compared fairly on the basis of the stated function. In the case of SBA, defining one function would be difficult, since the functions of the products are being assessed. However, there should be a mechanism to ensure the products are being compared on equal terms. The needs of the intended users can be used as such mechanism. The intended users can be grouped as a societal group where there are common needs. These needs, once identified, can be used to relate to the functions.

In summary, LCA functional unit fixes the function of products, thus the quantity of materials and time span of the product life time. Conversely, SBA aims to address, measure, and compare the societal benefits and fixes the needs of specific social groups that the product serves during the product life time. This is illustrated in Figure 7-1. This means that products with different functions can be compared as long as they serve the stated social groups and meet the stated needs.

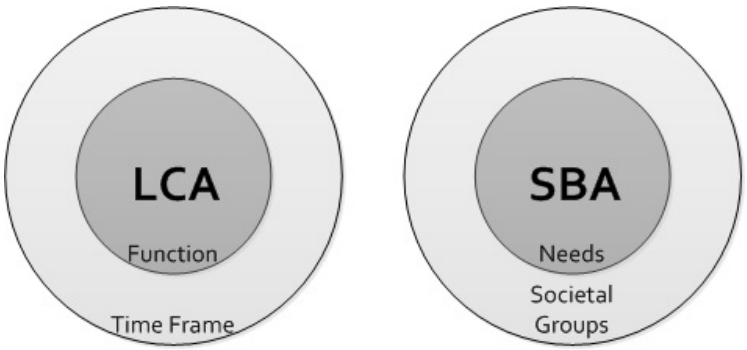

Figure 7-1 Comparisons of LCA and SBA assessment scopes

7.3.3.2 System boundary

System boundary is very important in LCA, for it determines the amount of data required to be collected in the study. LCA systems can be broadly described as a standard input to output structure with balance of mass. The boundary requirement for SBA would be similar in terms of determining what data is needed. The functions of products would be considered in the assessment, however most products have more than one functions. Only the intended functions should be considered, for it is difficult to account for all unintended misuses of products and should not fall into the remit of the assessment. Decisions to include or exclude any functions and features of products to be assessed should be recorded clearly and transparently, as these decisions can have very big effects on the results. Common misuses of products that are caused by poor design may be recorded if such misuse has an actual effect to the social groups. for example, an electric toaster that have wheels and was made to look like a racing car, younger member of a household might injure themselves by playing with a fast moving, burning toasters that should not be played in first place.

7.3.4 Inventory Analysis

There are two key steps in life cycle inventory analysis (LCI); data collection and data calculation. LCI identifies and quantifies the amount of materials and energy used for all the processes. These materials and energy used are related and calculated to the unit process and functional unit. An inventory analysis is also required for SBA, though the inventories are different. Inventory analysis would be the appropriate phase to assess the functions of products. The functions of the products are the inventories being identified and quantified, and they will be related to the needs of the societal groups, this is illustrated in Figure 7-2.

7.3.5 Impact Assessment

Life cycle impact assessment (LCIA) calculates the impacts by assigning LCI results to selected impact categories. There are three mandatory steps in LCIA; impact category and indicator selection, classification, and characterisations. The most appropriate impact categories and indicators are selected for the assessment purpose highlighted in the goal and scope phase. Classification is where the LCI results are assigned to impact categories, identifying the causal relationship between inventory data and impacts. Characterisation is the process that calculate the LCI results into impact indicators. Table 7-1 shows the three mandatory steps in LCIA and SBA for impact assessment. Similar to LCIA, SBA would need to the identify and select what kind of benefits were brought about by the stated functions. it

would also need to classify the inventory results to the benefits and characterise the benefits into scores. In summary, SBA will need to identify the benefits of functions and clearly presents the casual relationships between functions and benefits for characterisation.

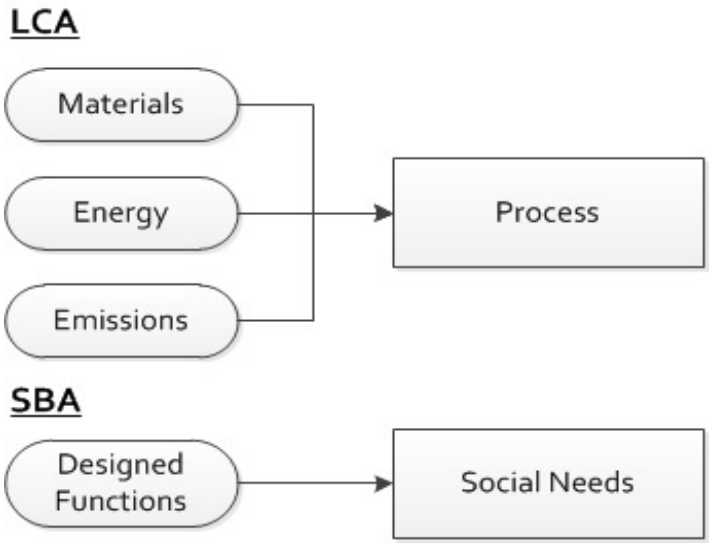

Figure 7-2 Comparisons of LCA and SBA inventory analysis process

Table 7-1 Mandatory steps in LCIA in LCA and benefit assessment in SBA

LCIA	SBA
1. Select impact category and indicator	1. Identify and select benefits
2. Classification (assign LCI results to impact category)	2. Classification (assign inventory results to benefits)
3. Characterisation (calculate indicator)	3. Characterisation (calculate benefits)

7.4 Societal Benefit Assessment Framework Structure

The following section describes the SBA framework structure, the steps that are involved in each phase, the data required, and how the data flow from one phase to another. The overall structure of SBA is illustrated in Figure 7-3. Similar to the LCA framework, SBA framework has four phases: societal goal and scope, functional inventory analysis, benefit assessment, and interpretation. Societal goal and scope phase set the foundation and boundaries of the assessment, functional inventory analysis quantifies performance of product functions, benefit assessment relates product functions from previous phase to societal benefits, and finally, interpretation phase evaluates the results from phase 2 and 3 in relation to the goal and scope set in phase one. The process is iterative, as shown by the arrows pointing back to each of the phases

7.4.1 Phase 1 - Societal Goal and Scope Definition

The societal goal and scope definition phase is made up of five parts: Applications and target audience of assessment, assumptions and limitations, societal groups definition, societal needs distinction, and establishing data source and collection method. The goal of SBA should be clearly stated, and the assessment should centralise around it. The main aim of SBA is to assess the societal benefits of products, on the other hand, there are various applications of SBA. It can be used for detailed analysis of societal benefits, gaining general understanding of inherent societal benefits of products. The results can be used to establish benchmark performances of product to comparing products or product groups, and to support future manufacturing and marketing decision. The purpose of the study should be clearly stated. This may be formulated as a question posed to the SBA study. Examples of such questions are the following:

- Where are the improvement possibilities in functionalities of the product to enhance its societal benefits?
- Which are the functions that contribute to the most benefits to the users and their wilder societal groups?

The audience of the assessment should also be stated, this will further clarify the level of details and presentations requirements for the latter phases of the assessment. Potential audience of the assessment can be business owner and board members, public policy makers, and public relations managers. The level of details required for each of these will vary and the focus will also differ.

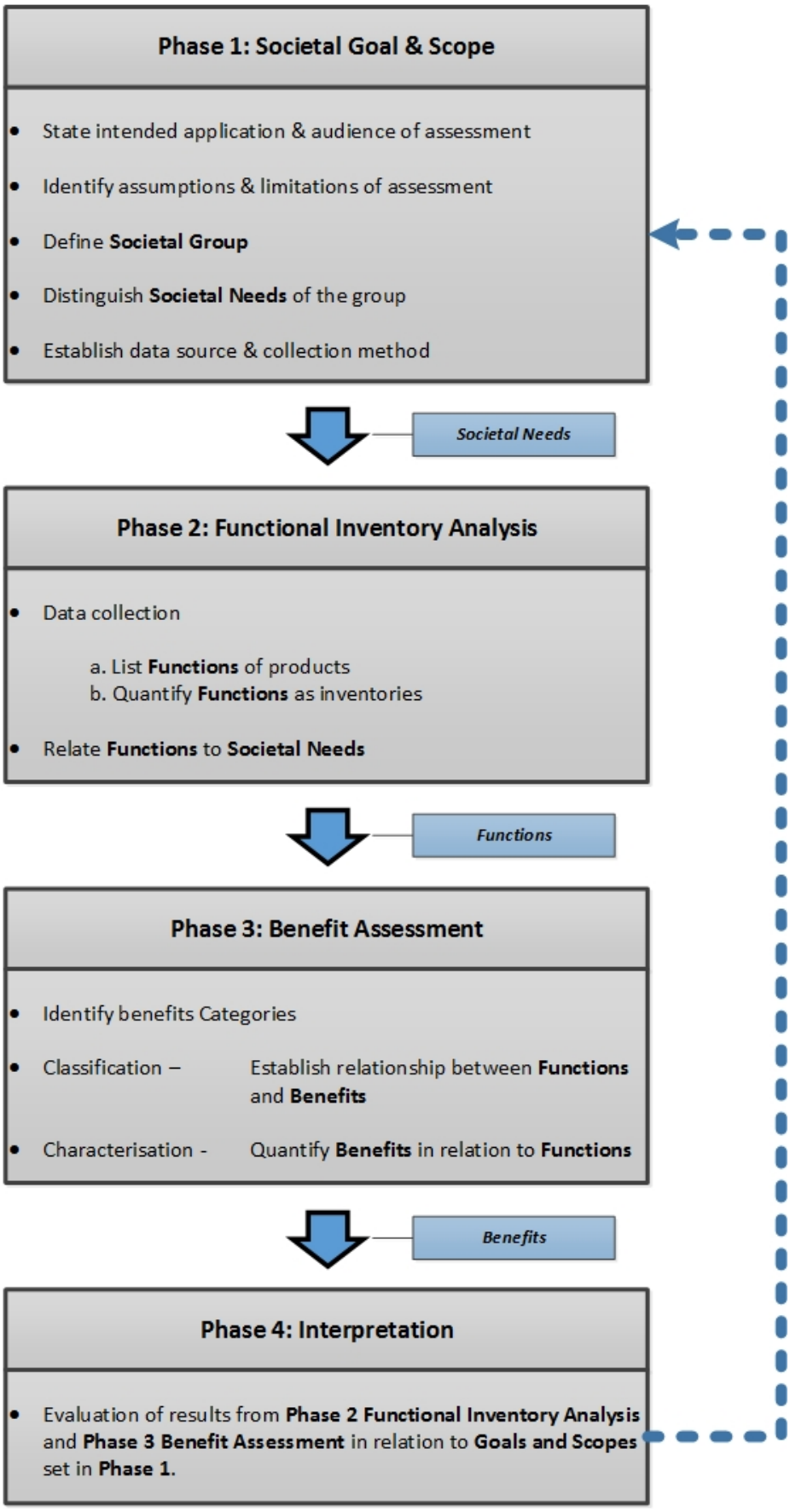

Figure 7-3 Societal Benefit Assessment framework

7.4.1.1 Societal group and needs

In SBA, products are assessed in their designed functions' ability to fulfil the needs of a certain social groups. This enables products to be compared fairly, as long as they are designed to fulfil the same needs for the same social group. It would be difficult to argue that a certain group's needs are more important over the others'. Social groups are most commonly defined by age as the distinction of needs are easily noticeable, but the scope the group can be expanded or reduced to either include or specify to people with special needs, such as wheelchair access. The needs should also be clearly defined for further analysis or results and comparisons with other products.

After setting the goals and scope, and defining the societal groups and needs, the data needed for the assessment and collection methods are required to be set. There is a need to distinguish whether the data is qualitative or quantitative, as it would indicate the method of collection, which can be questionnaires or some form of multiple criteria decision-making techniques which quantify qualitative factors. For quantitative data, measuring methods and instruments can be determined. The output of this phase is the establishment of the societal needs, which results from latter phases can be related to.

7.4.2 Phase 2 - Functional Inventory

This phase of SBA focuses on the products and aims to relate functions to the societal needs established from the previous phase. The first action of this phase is to list the functions of the products being assessed. SBA will have to generate a thorough list of functions of the product. Information from designers and manufacturers on how the products are used would be helpful. For more accurate recording of data, observation on the products being used is also preferable. The functions listed will have to be quantified as measurable inventories to relate to societal needs. It is important to understand how well the functions are performed in relation to the societal needs and how important such functions are to the intended societal groups. Expert opinions can increase understanding of specified social groups and their needs.

7.4.3 Phase 3 - Benefit Assessment

This phase is where the functional inventories are related to the benefits. Similar to its LCA counterpart, there are three steps in this phase: identify benefits categories, classification, and characterisation. Relevant benefits should be identified and listed as a first step in this phase. It is important to capture all the benefits that are related to all the functional inventories, communication with product designers and expert opinions can help to ensure that. The next

step is classification where the causal relationship between the functional inventories and the benefits are established. These benefits are calculated into indicators for interpretation in the characterisation step. Unlike Life Cycle Impact Assessment (LCIA), where characterisation models are required for situations that have multiple impacts for one inventory unit, having one function that brings multiple benefits does not matter as much, and no allocation method is required. However, it is essential to determine how well the functions garner these benefits. Optional steps like grouping and weighing can be performed to adjust the assessment results to present a more accurate case for specific situations and social groups.

7.4.3.1 Characterisation

In SBA, the ultimate benefit of product is assumed to be contribution to social harmony, thus a functioning sustainable society. The relationship of between function to this ultimate benefit is often unclear. Similar to the cause-effect chain of environmental impact, a chain of benefit can be established (Figure 7-4). The relationship between product functions and the primary benefits to the users are most apparent, however the link between the primary and secondary benefits are not as clear and less scientific. The causal relationships will be more and more unclear as there is more level of benefits.

7.4.4 Phase 4 - Interpretation

This stage of SBA aims to reach conclusions, analyse results, explain any limitations, provide recommendations for redesign and report the results clearly and transparently. The soundness and robustness of the assessment should be verified. It is essential to identify significant issues and evaluate results for sensitivity, consistency and completeness before conclusions are reached where recommendations are proposed. It is also important to note the inherent iterative nature of the assessment, just like its LCA counterpart. Only through reassessing and adjusting with new key information that the assessment can be relied on.

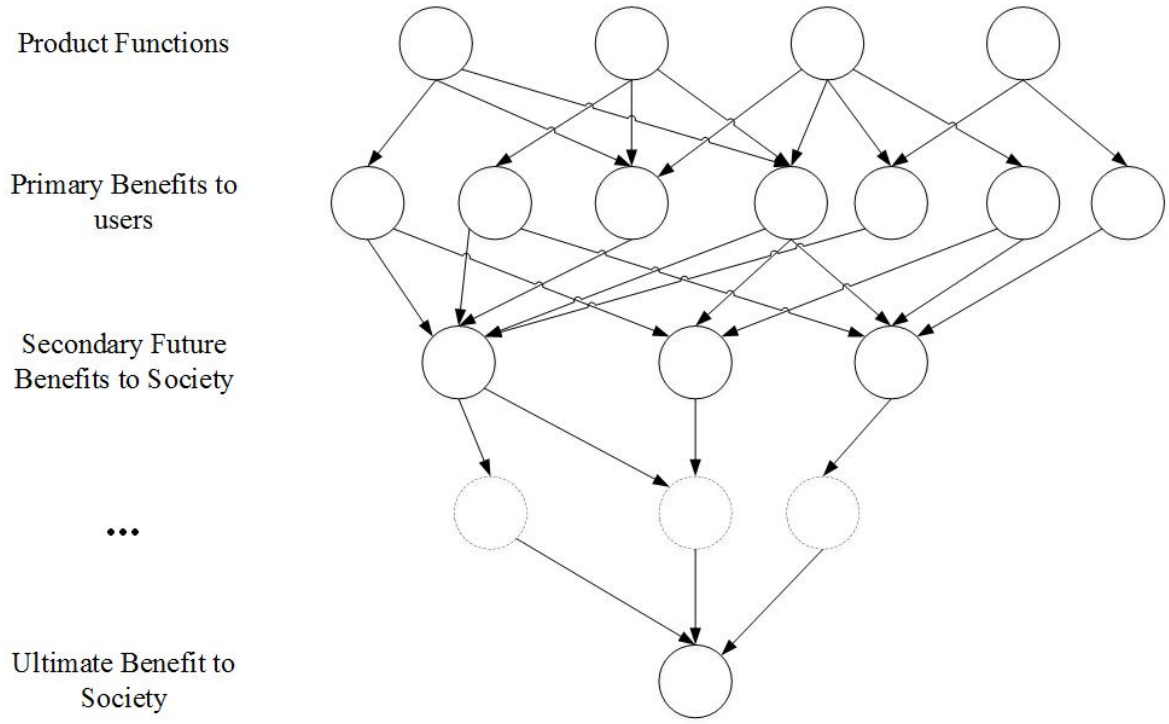

Figure 7-4 Benefit Chain of benefit characterisation

Figure 7-5 highlights the main difference between the LCA and SBA frameworks. SBA collects data in the form of functions and societal benefits are classified and characterised from them. Whereas functions are expressed in the form of a functional unit in LCA.

7.5 Chapter Summary

This chapter has outlined the concepts of the framework for societal benefits assessment of product to the users during the product's use phase. This chapter defined the term societal benefit. The chapter also described the development of the SBA framework, and discussed the research decision and justification for adapting the ISO 14040 LCA framework as the foundation for the development of the SBA framework. Key differences between the SBA framework and the LCA framework have been discussed. The chapter ended on the description of the structure of the SBA framework and the process and data that are required for such assessment. The development of a SBA method is described in Chapter 8.

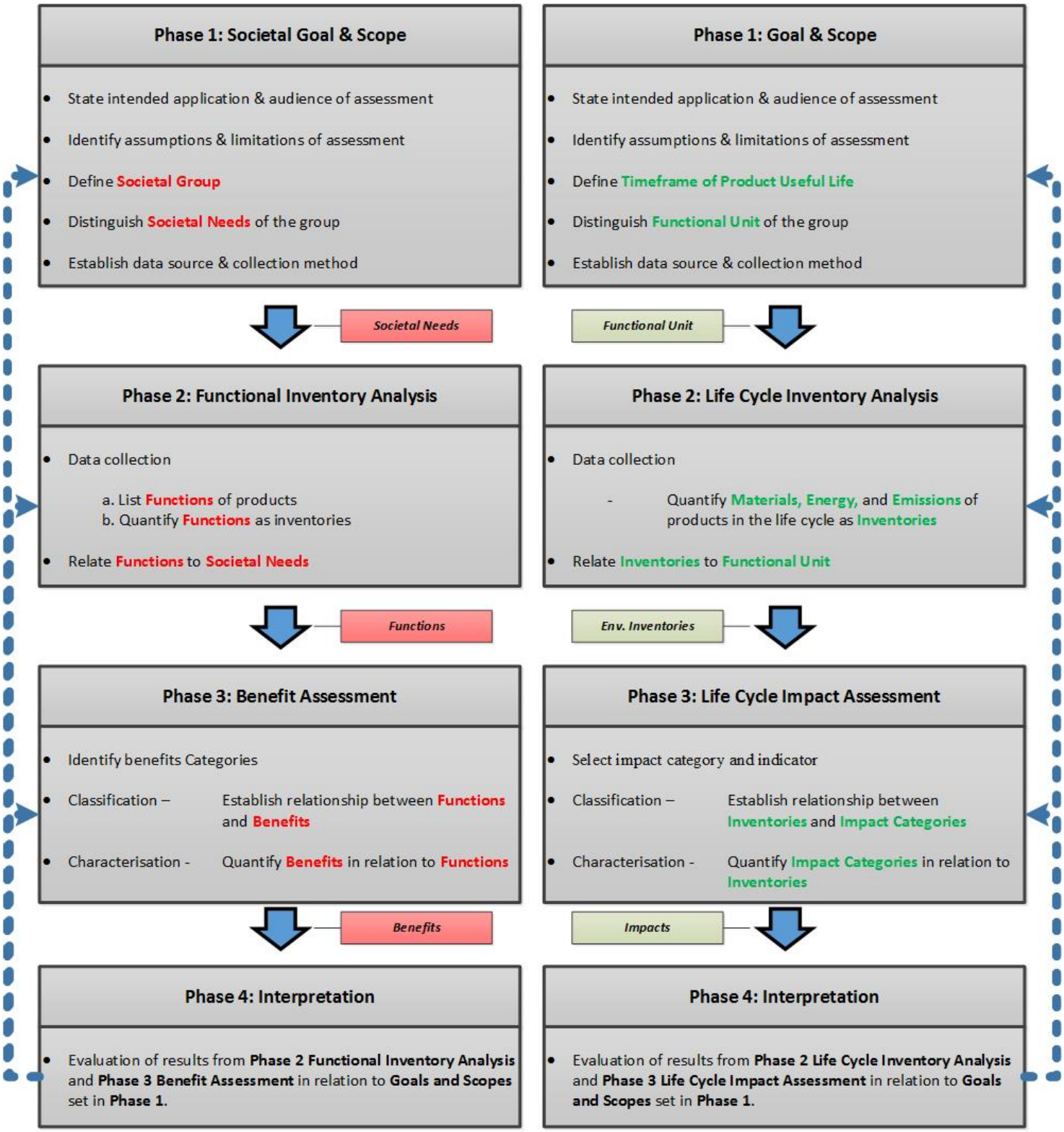

Figure 7-5 Side by side comparison of LCA and SBA framework

Chapter 8 Societal Benefit Analysis and Assessment Method

8.1 Introduction

The previous chapter presented the SBA framework developed during this doctoral research project. The four-phase framework described in this chapter includes a function analysis phase, followed by a benefit assessment phase. Whilst the framework has identified a systematic approach to investigating and quantifying a product benefit to society, it has not yet developed a method for how these phases could be supported in practice. This chapter details a method developed as part of this research, for supporting the implementation of this framework. The approach taken and described in this chapter was to select a specific product category and social group and develop the method to allow this assessment to be made. The key principles underlying this method can be applied to a broad range of products and societal groups, but the functions and benefit categories used are comprehensive only within the selected scope of this study. This chapter begins with the rational for the selection of the product category and social group (Toys & 2-4-year olds UK). The method developed to support each of the phases are then described in detail and the chapter concludes with a summary of the key findings.

8.2 The Suitability of Toys as Research Focus

Toys and the companies that produce them are highly diverse in terms of their sustainability values. Whilst some manufacturers take a very responsible approach to social and environmental considerations both in the design of their products and their manufacturing operations, others are less so. A walk down the aisle of any major toy store will reveal a huge diversity of products ranging from those intended purely for entertainment to the educational and instructive. Some toys are even cited as promoting negative social outcomes such as stereotyping of boys and girls or normalising undesirable behaviour (guns, gambling, and criminality). In the main, toys are generally promoted based on their capability to excite, entertain and teach children rather than on their environmental credentials, although progressive companies are beginning to include environmental considerations in the design and manufacture of their products. It was stated previously in chapter 3 that, in the UK alone, on

average 44 new toys are bought for a single child every year, which amass to 238 throughout his/her childhood. Despite this vast number, the results of a questionnaire-based survey of parents revealed that only about 12 of the 238 toys were regularly played with. Based on these findings it seems reasonable to assert that the supply and sale of toys greatly exceeds the actual needs of the child and materials are therefore consumed needlessly and do not provide a return on their investment. In order to help parents, select toys which can provide the greatest benefit to the child and provide a longer return on their investment, there is a clear need for a means to quantitively assess the play benefits of toys such that comparisons can be made, and informed purchasing decisions taken. Once implemented companies would be encouraged to adopt this approach during the design stage to achieve a competitive advantage both in sales and ultimately in securing future scarce resources by demonstrating the benefit of their products to society. The following section describes the method developed for undertaking an SBA using the evaluation and comparison of two non-gender specific products aimed at 2-4 year olds, specifically a traditional soft toy and one with an embedded interactive electronic music device.

8.3 Societal Benefit Assessment Method

The SBA method was developed to implement each of the four phases of the framework from the previous chapter. It comprises of Goals and scopes, Functional inventory analysis, Benefit assessment, and Interpretation. Goals and scopes phase set the background and defined the targeted user groups of the toys and their needs. The functional inventory analysis phase identifies the designed functions and establishes their importance to the users regarding their needs. The societal benefits are calculated during the benefit assessment phase, which classify and characterise the functional inventories from the previous phase to different benefit categories. The interpretation phase is where the results are analysed. The overall structure of the SBA method and the steps within each phase are illustrated in Figure 8-1.

8.3.1 Goals and Scope

Two dolls were selected to be assessed for the demonstration and improvements of the SBA method. The goal of this study is to provide a point of focus for the development of suitable assessment methods and to demonstrate their application in terms of quantifying benefits and the interpretation of results where opportunities for improvements are highlighted. This study will also demonstrate how the results obtained can be used to compare these products based on their relative societal benefits.

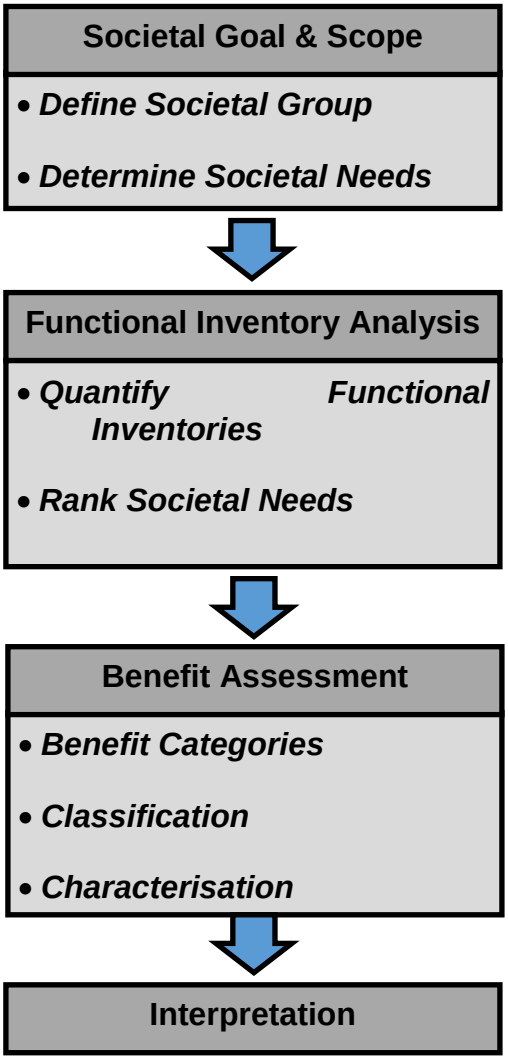

Figure 8-1 Overall structure of SBA method

8.3.1.1 Product description

Toy A is a doll that is made to resemble an original children's TV show character. The toy is made with soft, colourful, and tactile fabrics for a plush feel for comfortable cuddling as well as playing. It is filled with polyester doll-stuffing that gives a firm but soft feel when squeezed. The doll is approximately 34 centimetres tall. The doll can be played in several ways; it's most straightforward use is to be cuddled, hugged, and felt, the fact that it can be sat upright on its own greatly enhances role plays, and it can be incorporated in storytelling.

Toy B is also a soft cuddling toy, but it has electronic instruments installed inside. It is made to resemble the same character as Toy A. The doll is made of the same or similar fabrics

to Toy A, however, the feet are made of polypropylene for the mechanical movements from the electric motor embedded inside. In addition to the polyester stuffing, there are nylon casings and gears, electric motor, printed circuit board, screws and fixings, and 3 standard AA batteries. It is approximately 30 centimetres tall. The doll has complex electronics embedded that allows it to interact with children with more than 70 phrases, various moves and dances, and music. These features allow greater interactions between child and toy, however, it somewhat limits the "free" element of toys and slightly hinders role play. Details of Toy B is shown in Figure 8-2.

a. Electronic motors and gear drive system.
b. Fabric casing and padding.
c. Motor and battery casing, mechanical feet, and 3 AAA batteries.
d. Polyester stuffing.

Figure 8-2 Disassembled Toy B

8.3.1.2 Social groups and needs

The social groups that the two toys serve are 2 to 4 years old children. It is acknowledged that children and adults much older would keep their soft toys (Langsworthy, 2015). However, the primary designed purpose of soft toys for adults would be changed to comfort and emotional wellbeing rather than being played. It is therefore important to define "play", "play value" and "play benefits". As mentioned in chapter 5, Kudrowitz and Wallace (2010) defined "play" as the quality of mind during enjoyable, captivating, intrinsically motivated and process focused activities. They further expounded that "play value" of toys as the affordance of play, that is the ability of toys to provide or stimulate the quality of mind during enjoyable, captivating, intrinsically motivated and process focused activities. This definition of play value focuses mainly on the action or activity of play and the affordance of an enjoyable, captivating, and intrinsically motivated play from the toys. On the other hand, "play benefits" focus on the effects that are created after play. In this research societal benefits are investigated in the perspective of contributions to societies, thus, the central need for any toy users, children, is their development in all aspects that will lead to future positive impacts. Therefore, play benefits are the skills and growth that are developed through playing, as summarised in Table 5-4 in Section 5.4.3 of Chapter 5. Thence, play value may be closely related to play benefits, but they are not the same. The higher the play value that a toy brings the more effective it is benefiting child's development. And play benefits are the results of fulfilling the need to use toys as a tool to aid child development.

The scope of the assessment focuses on toys that are aimed at children of 2 to 4 years old. It would be a different and separate assessment for the same toys and other toys that are aimed at another age group. This age group is chosen for the more apparent need and benefit relationship, as early child development has more focus on initial physical and cognitive development as opposed to more emotional wellbeing and self-identity development in later ages. There are three main needs that toys satisfy: child development, entertainment, and time occupying. Child development is the ability to help the child grow in their skills, such as physical, cognitive, and social interaction skills. Entertainment refers to the ability to amuse and excite the children. Time occupying is a need that is for parents, while the toy takes away the attention of the child and allow the parents to perform other tasks or simply rest.

8.3.2 Functional Inventory Analysis

The second stage of the SBA method is functional inventory analysis. There are three steps involved in this stage, namely Quantify functional inventories, Ranking societal needs, and Relate inventories to needs. The functional inventories are defined and measured in the first step. This is followed by the second step which establish a hierarchy of importance of the functions to children of 2 to 4 years old. Figure 8-3 illustrates the structure of the functional inventory analysis stage. The third and last step associate the functional inventories from step one with the importance from step two. The following sections will describe the functional inventory analysis stage in more detail.

8.3.2.1 STEP ONE - Quantify Functional Inventories

In order to quantify and measure functional inventories of toys, the functions are required to be defined. The functional inventories are essentially the play types of toys in this case, as this method is developed for the toy industry. The play types defined and used in this case study are: sensory play, construction play, challenge, fantasy, social play, solitary play, free play, play with rules, mental play and physical play.

- Sensory play refers to how the toys and play feels, looks, smells, tastes and sounds.
- Fantasy play refers to the toy's ability to put player into a world or state of mind that is outside of the ordinary.
- Construction play refers to toys and play that allows users to create.
- Challenge play refers to play that tests one's abilities against others or oneself.

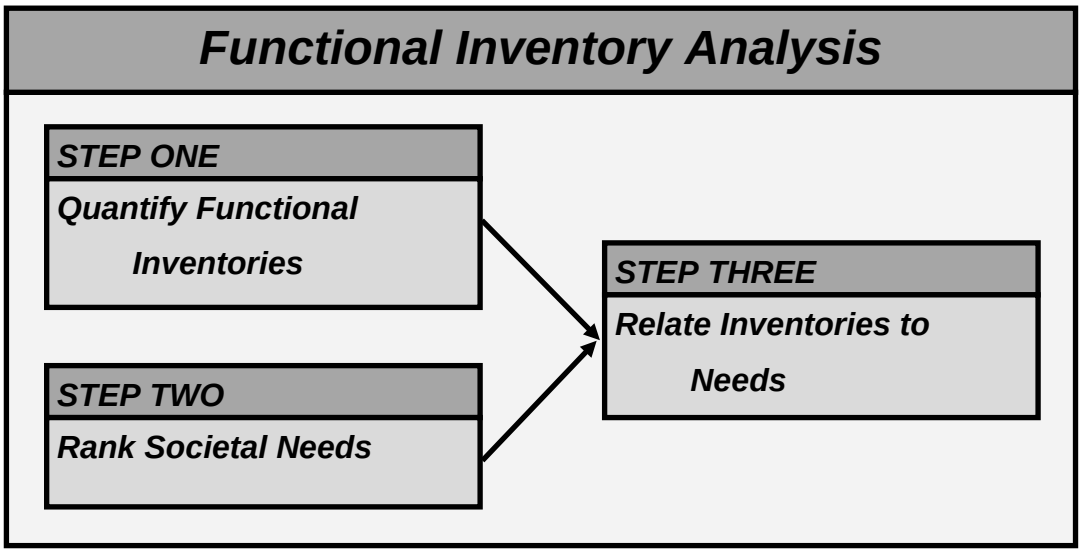

Figure 8-3 Functional Inventory Analysis structure

The rest of the play types can be referred to as play characteristics, they refer to the atmosphere or the situation for which the toys are played in. For example, social play and solitary play refers to whether the toys enable children to play together or alone. One toy can be played both socially and solitarily and may bring different benefits from several types of play. This is also the case for free play vs play with rules, and mental vs physical play.

All the play types are scored from 0 to 10, where 0 means the toy being assessed does not afford that type of play and 10 means it fully affords that type of play. The rating system intends to assess the performance on each play types by the toy. Scoring guides were drafted to provide consistent scoring criteria for each type of play. Table 8-1 shows the scoring criteria for sensory play. The full scoring criteria can be found in Appendix 4. It is envisioned that the scoring can be carried out by toy designers or any users with partial knowledge of toys and child development.

Table 8-1 Scoring criteria for sensory play

Play Type	**Score**	**Performance Criteria**
Sensory Play	2	The toy can capture the playing child's attention with one type of sensory play.
	4	The toy can capture the playing child's attention with more than one type of sensory plays.
	6	In addition to caption the playing child's attention with more than one type of sensory plays, the toy should be able to sustain the child's interest for a longer period.
	8	Rather than capturing the child's attention and sustaining his/her interest, this toy should be engaging and captivating. It should be able to provide opportunities to explore the child's use of senses.
	10	The toy should be able to do all the above with a seamless integration of all the different sensory plays. It would provide an engaging and captivating playing experience in which the child would be encouraged to explore his/her senses and engage with his/her surroundings through the toy.

8.3.2.2 STEP TWO - Rank Societal Needs

It is important to assess whether the play types are relevant to the target users. After all, performing well in a play type that is not most suitable for a child is not the most effective use of the toys and resources. The play type ratings are weighted with importance scores. These importance scores are generated by utilising the Analytical hierarchy process (AHP) where pairwise comparisons of each play types were evaluated and scored. The scores are calculated according to the Saaty (2008) method and weighted by their importance to child development to children between the ages of 2 to 4. This process is performed by experts in child development to introduce expertise and reduce subjectivity.

8.3.2.2.1 Analytical Hierarchy Process

AHP, developed by Saaty (1980), is a one of the more recognised approaches to multi-criteria decision making. It allows the consideration of both quantitative and qualitative factors in selecting the best alternative option with a number of criteria. It can also be used to establish a hierarchy of importance for the criteria considered. This methodology is only concerned with establishing the priority weight of the play types relating to the toys and the toys' target users.

Therefore, a full AHP is not performed but rather the pairwise comparison method that determines priority weights of each play type. Pairwise comparisons will be performed by experts in child development, in this case Dr Amanda Gummer, alongside the stakeholders who took part in the scoring of play types. The stakeholders are envisioned to be toy designers and toy company managers, in the case of this study the researcher stood in. To perform pairwise comparison analysis, a value is chosen from a scale to express the relative significance of one alternative over another based on a fundamental scale of 1 to 9, as shown in Table 8-2 (Saaty, 2008). For example, Sensory Play is considered to have moderate importance over Challenge Play for children between the age of 2 to 4, therefore it will be 5 from Sensory to Fantasy, and 1/5 for Fantasy to Sensory, see Table 8-3. The number of pairwise comparisons required are determined by the number of alternatives needed to be compared, the following formula can calculate it:

$$N=n(n-1)/2$$

Where N is the total number of comparisons required, and

n is the number of play types

In this case, there are 10 play types (alternatives), and therefore 45 comparisons are needed. A judgment matrix *A* is generated with *i* rows and *i* columns, where *i* is the number of alternatives being considered from the set of pairwise comparison of the alternatives, as shown in Table 8-3. A list of priority weights is calculated for weighing functional inventories from step one.

Table 8-2 Saaty scale of pairwise comparison

Numerical Rating	Definition
1	Both criteria equally important
3	Slight importance of one criterion over the other
5	Moderate importance of one criterion over the other
7	Demonstrated importance of one criterion over the other
9	Extreme or absolute importance of one criterion over the other
2, 4, 6, 8	Intermediate values between two adjacent judgements

Table 8-3 Pairwise comparison matrix

	Sensory	Construction	Challenge	Fantasy	Social Play	Solitary Play	Free Play	Play with Rules	Mental	Physical
Sensory	1	3	5	6	9	7	5	8	4	2
Construction	1/3	1	3	4	7	6	2	8	2	1/2
Challenge	1/5	1/3	1	2	8	3	1/2	3	1/5	1/7
Fantasy	1/6	1/4	1/2	1	6	2	1/4	2	1/2	1/7
Social Play	1/9	1/7	1/8	1/6	1	1/5	1/7	1/3	1/8	1/9
Solitary Play	1/7	1/6	1/3	1/2	5	1	1/5	2	1/2	1/8
Free Play	1/5	1/2	2	4	7	5	1	2	1/2	1/2
Play with Rules	1/8	1/8	1/3	1/2	3	1/2	1/2	1	1/6	1/8
Mental	1/4	1/2	5	2	8	2	2	6	1	1/2
Physical	1/2	2	7	7	9	8	2	8	2	1
Sum	**3.0**	**8.0**	**24.3**	**27.2**	**63.0**	**34.7**	**13.6**	**40.3**	**11.0**	**5.1**

The priority weights for each alternative are calculated in two steps as follows:

i. Step A: A normalised matrix is obtained from the judgement matrix by dividing each entry in each column by the total of that column (Table 8-4)

Each entry for the normalised matrix is calculated by the formula below:

$$a_{ij}^{*} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}$$

For all $j = 1,2, \dots, n$

Where:

- a_{ij} is the expert judgement.
- a_{ij}^{*} is the normalised expert judgement.

For example (sensory: sensory) is 1/3, where 3 is the sum of the pairwise comparisons of the sensory column. Therefore, it is 0.33.

Table 8-4 Normalised relative weight

	Sensory	**Construction**	**Challenge**	**Fantasy**	**Social Play**	**Solitary Play**	**Free Play**	**Play with Rules**	**Mental**	**Physical**	**Sum**
Sensory	0.33	0.37	0.21	0.22	0.14	0.20	0.37	0.20	0.36	0.39	**2.74**
Construction	0.11	0.12	0.12	0.15	0.11	0.17	0.15	0.20	0.18	0.10	**1.41**
Challenge	0.07	0.04	0.04	0.07	0.13	0.09	0.04	0.07	0.02	0.03	**0.59**
Fantasy	0.06	0.03	0.02	0.04	0.10	0.06	0.02	0.05	0.05	0.03	**0.44**
Social Play	0.04	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.02	**0.14**
Solitary Play	0.05	0.02	0.01	0.02	0.08	0.03	0.01	0.05	0.05	0.02	**0.34**
Free Play	0.07	0.06	0.08	0.15	0.11	0.14	0.07	0.05	0.05	0.10	**0.88**
Play with Rules	0.04	0.02	0.01	0.02	0.05	0.01	0.04	0.02	0.02	0.02	**0.25**
Mental	0.08	0.06	0.21	0.07	0.13	0.06	0.15	0.15	0.09	0.10	**1.09**
Physical	0.17	0.25	0.29	0.26	0.14	0.23	0.15	0.20	0.18	0.19	**2.06**

ii. Step B: The average of each row is obtained by adding the values in each row of the normalised matrix and dividing the sum by the number of entries in each row. The result is the priority weight of the alternative (Table 8-5).

The priority weights are calculated following the formula below:

$$w_i = \frac{\sum_{j=1}^{n} a_{ij}^*}{n}$$

For all $i = 1,2, \dots, n$

Where:

- w_i is the weight.

In the case of sensory play's priority weight is 2.74/10, therefore it is 0.27.

Table 8-5 Priority weights

Play Types	Priority Weight
Sensory	0.27
Construction	0.14
Challenge	0.06
Fantasy	0.04
Social Play	0.01
Solitary Play	0.03
Free Play	0.09
Play with Rules	0.03
Mental	0.11
Physical	0.21

8.3.2.2.1.1 Consistency Check

The number of play types assesses is highly likely to create contradicting pairwise comparisons. Contradicting pairwise comparisons will create inconsistencies in the overall judgement. For example, A can be weighed higher than B, and B higher than C. Inconsistency is created if C was weighed higher than A, as the comparison contradict the first two comparisons. Saaty (2008) developed the consistency index (*CI*) as a metric for measuring inconsistency amongst the pairwise comparisons.

A maximum eigenvalue (*λmax*) is required for calculating *CI*. An eigenvector of a given linear transformation is a vector whose direction is not changed by that transformation. The corresponding eigenvalue is the proportion by which an eigenvector's magnitude is changed. *λmax* can be computed by summing each column of the judgement matrix and multiplying those sums by the corresponding priority weight. The judgement matrix has an eigenvalue equal to *n* (where *n* is the number of variables or criteria) if the comparisons are perfectly consistent. However, the maximum eigenvalue is greater than *n* if the comparisons are not perfectly consistent. The difference between *λmax* and n is expressed as the consistency index, which is computed as follows:

$$CI = \frac{\lambda_{\max - n}}{n - 1}$$

where

Cl = consistency index

λmax = maximum eigenvalue

n = number of variables or criteria

A consistency threshold is established by comparing *CI* to the average *CI's* of 500 randomly generated matrices of the same dimension (*RI*), as shown in Table 8-6. The rating can be regarded as consistent if the consistency ratio (*CI/RI*) of the comparison matrix is less than or equal to 0.10 (i.e. 10% inconsistent or 90% consistent). It is recommended that the pairwise comparisons are to be revised to improve the consistency of the comparisons. The consistency radio is 0.09 for this study, therefore the inconsistency is acceptable.

Table 8-6 Random consistency indices (adopted from Saaty 1996)

Size of Matrix (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

8.3.2.3 STEP THREE - Relate Inventories to Needs

With the functional inventories scored and the priority weight computed, the two are related for the inventories to be relevant to the importance of the child development for the specified age range. First of the priority weights are normalised. This is performed so the inventory values will not be too small to work with for later benefit assessment stage. the normalised priority weights are as shown in Table 8-7 along with the play types and the original weights.

Table 8-7 Normalised priority Weights

Play Types	Priority Weight	Normalised Priority Weight
Sensory	0.27	100%
Construction	0.14	51%
Challenge	0.06	21%
Fantasy	0.04	16%
Social Play	0.01	5%
Solitary Play	0.03	12%
Free Play	0.09	31%
Play with Rules	0.03	9%
Mental	0.11	39%
Physical	0.21	74%

The play type scores are weighted by multiplying with the importance scores (priority weights). Table 8-8 shows the functional inventory scores of Toy A and B, alongside their respective weighted scores. The priority weights are also show in the table. The toys were assessed and scored by a panel of child development experts and toy designers. The results indicate that Toy B has better performance in general, as the battery-operated toy can afford better sensory stimulations, thus better fantasy affordance as well.

8.3.3 Benefit Assessment

The final stage of SBA method is benefit assessment. There are three steps in benefit assessment: identify benefits, classification and characterisation. The first step is to identify what benefits are brought about from playing. These benefits are identified from literature reviews from Section 5.4 of Chapter 5. The benefits from playing that are assessed are focused in child development, it is further summarised into 6 groups: Creativity, Social Behaviour, Communication, Cognitive Development, Physical Skills, and Emotional Well-being. Table 8-9 listed these benefits along with the subcategories.

Creativity – Children at between the age of 2 to 4 will start showing signs of development in imagination, ability to come up with new and unusual ideas, the ability to generate a variety of different ideas through divergent thinking, and ability to apply knowledge and imagination to different situations.

Table 8-8 Final weighted functional inventory scores of Toy A and Toy B

	Priority Weights	Toy A Functional Inventory Scores	Weighted Toy A Functional Inventory Scores	Toy B Functional Inventory Scores	Weighted Toy B Functional Inventory Scores
Sensory	100%	6	6.00	8	8.00
Construction	51%	1	0.51	2	1.01
Challenge	21%	1	0.21	1	0.21
Fantasy	16%	5	0.78	7	1.10
Social Play	5%	3	0.15	5	0.25
Solitary Play	12%	8	0.98	8	0.98
Free Play	31%	10	3.15	7	2.20
Play with Rules	9%	1	0.09	2	0.18
Mental	39%	2	0.78	4	1.56
Physical	74%	7	5.15	7	5.15

Table 8-9 Benefit categories and subcategories

Child Development Benefits Categories	Benefit Subcategories
Creativity	
Social Behaviour	
Communication	Linguistic & Language
	Other Representational Abilities
Cognitive Development	Logical/Critical Thinking
	Basic Physics/Mechanism
Physical Skill	Fine Motor Movement
	Gross Motor Exercise
Emotional Well-being	Parent Attunement
	Meta-cognitive development
	Peace Affordance

Social behaviour – children at the age of 2 will start to interact socially, with parents and other children (with encouragement and help). At this age, there will not be much interaction but coping and mimicking is possible. Towards the age of 3, children will start to be able to take turn in some activities and towards 4 years old, they will start to be able to cooperate with each other.

Communication – children at this age should be adept in communicating nonverbally. Their vocabularies are also developing rapidly. By three years old, they should know about 300 words and can string simple sentences together. Children this age will begin to converse with others, mostly parents as there might be a barrier in conversing with people outside of his/her trust circle.

Cognitive – mental capabilities are developing at this stage. Children will be able to have conversations that have meaning and can communicate with parents and family. They will be able to identify and distinguish colours and shapes. Later in their development, they will start to recognise numbers and may be alphabets. They will also start to grasp the idea of time and placement such as top, bottom, under, left and right. Problem solving abilities are mainly performed through trial and error. Children will also start to understand and comprehend hazardous situations, such as burning fire and shape knifes.

Physical – toddlers develop their muscles rapidly at 2 to 3 years old. They will be able to run and have enough strength to stand on one foot. They will start to develop control to perform more complex and coordinated tasks, such as chasing and walking up and down stairs. In terms

of fine motor control, children will be able to pick, drop, and stack/place objects. More coordinated tasks are possible to be performed.

Meta-cognitive (emotional wellbeing) – children will start to develop a sense of identity. They will start to be able to distinguish between genders and understand their body parts. They will start to experience their own feelings and may struggle to express or communicate their feelings. They will also start to be able to comprehend others' feelings, mainly through facial expressions.

Parent attunement - children who are securely attached in childhood tend to have good self-esteem, strong social relationships, and the ability to feel comfortable to share of themselves with others. On the other hand, children who do not form secure attachments can have a negative impact on their behaviour in later childhood and throughout their lives.

Peace affordance – as well as attachment to parents and family members, children may also form strong attachment to specific toys. The availability of the toy can provide a sense a calming sense to the child. This in turn provide emotional stability and this habit can even carry to adulthood (Langsworthy, 2015).

8.3.3.1 Benefit Classification and Characterisation

In LCAs and SLCAs, classification refers to how inventory data relates to the impacts and where one inventory relates to multiple impacts, allocation method is used. This is not quite the case in SBA, as allocation is not suitable in SBA. This is because the functional inventories can relate to multiple benefits in various ways and splitting the inventory scores by allocation does not reflect the true situations. Therefore, an alternative method is developed; a classification matrix is devised as shown in Figure 8-4. For characterisation, the play types are characterised into play benefits where the play types are given scores of 0 to 5. A score of 0 means that particular play type does not contribute to those benefits and 5 means it strongly contributes to that play benefits. This assessment stops at the primary benefits from playing as it was difficult to determine the relationship between the primary benefits and further benefits. The time and data required are not achievable in this research, and it will form parts of further works and recommendation.

The Societal benefits score of each benefit is the sum of multiplication of the weighted inventory scores of each play type to the corresponding classification scores. The scores are shown in Figure 8-5, where the functional inventory (FI) score and the weighted functional

inventory scores are presented to the left of the classification model, and the societal benefit scores (SC) are listed on the first line below the model. The scores of each play benefits are divided by a theoretical maximum score to calculate the "potential fulfilled" of each play benefits. The theoretical maximum scores (TC) are calculated by having all the play types scored to maximum, i.e. 10. The benefit potential is presented in Figure 8-5 as percentages below the original scores, an overall average can be calculated as a single societal benefit score. Overall toy B has a score of 63% which is 22% higher than toy A at 41%. Figure 8-6 shows the detail results of the SBA on each benefit.

Classification Model	CHILD DEVELOPMENT										
	Creativity	Social Behaviour	Communication		Cognitive Development		Physical Skill		Emotional Well-being		
			Linguistic & Language	Other Representational Abilities	Logical/Critical Thinking	Basic Physics/Mechanism	Fine Motor Movement	Gross Motor Exercise	Parent Attunement	Meta-cognitive development	Peace Affordance
Sensory	0	0	0	1	2	4	2	1	1	2	4
Construction	5	2	0	1	2	5	4	1	2	3	4
Challenge	3	1	2	2	5	3	2	2	1	4	1
Fantasy	2	2	2	3	3	1	2	0	3	4	5
Social Play	2	5	5	3	2	0	0	0	2	3	2
Solitary Play	2	1	0	0	0	0	0	0	0	3	5
Free Play	5	1	0	0	0	0	0	0	0	5	4
Play with Rules	1	2	0	1	4	1	0	0	1	0	0
Mental	4	0	0	0	5	3	0	0	1	5	2
Physical	0	0	0	1	0	1	5	5	0	0	0

Figure 8-4 Classification model

FI	TM	PW	WFI	WTM	Toy A	CHILD DEVELOPMENT										
						Creativity	Social Behaviour	Communication		Cognitive Development		Physical Skill		Emotional Well-being		
Functional Inventory Scores	Theoretical Maximum Functional Inventory Scores	Priority Weights	Weighted Functional Inventory Scores	Weighted Teoretical Maximum Functional Inventory Scores				Linguistic & Language	Other Representational Abilities	Logical/Critical Thinking	Basic Physics/Mechanism	Fine Motor Movement	Gross Motor Exercise	Parent Attunement	Meta-cognitive development	Peace Affordance
6	10	100%	6.0	10	Sensory	0	0	0	1	2	4	2	1	1	2	4
1	10	51%	0.5	5.1	Construction	5	2	0	1	2	5	4	1	2	3	4
1	10	21%	0.2	2.1	Challenge	3	1	2	2	5	3	2	2	1	4	1
5	10	16%	0.8	1.6	Fantasy	2	2	2	3	3	1	2	0	3	4	5
3	10	5%	0.1	0.5	Social Play	2	5	5	3	2	0	0	0	2	3	2
8	10	12%	1.0	1.2	Solitary Play	2	1	0	0	0	0	0	0	0	3	5
10	10	31%	3.1	3.1	Free Play	5	1	0	0	0	0	0	0	0	5	4
1	10	9%	0.1	0.9	Play with Rules	1	2	0	1	4	1	0	0	1	0	0
2	10	39%	0.8	3.9	Mental	4	0	0	0	5	3	0	0	1	5	2
7	10	74%	5.1	7.4	Physical	0	0	0	1	0	1	5	5	0	0	0
					Societal Benefit Score per Category (SC)	26	7.8	2.7	15	21	36	42	33	11	41	49
					Therectical Max Score per Category (TC)	71	24	10	34	70	93	84	56	33	90	98
					Benefit Potential = SC/TC	37%	33%	28%	44%	30%	38%	49%	58%	33%	45%	51%
					Average	41%										

Figure 8-5 Societal Benefit characterisation calculations for Toy A

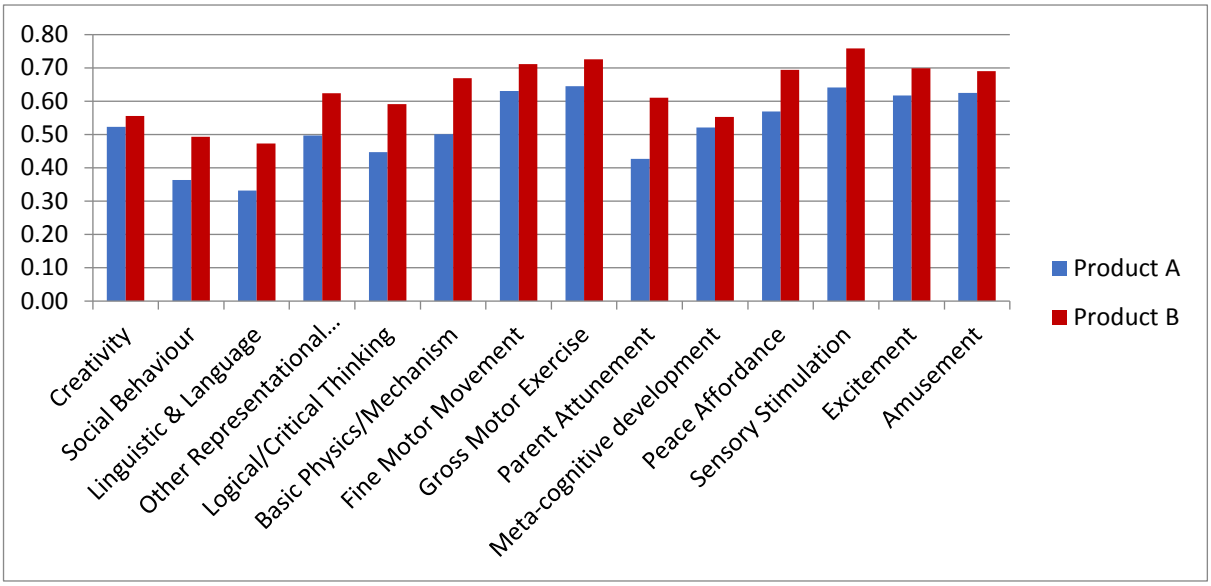

Figure 8-6 Detail results of benefit assessment for both toys

8.3.3.1.1 sensitivity analysis

A sensitivity analysis was carried to test the consistency of the scoring and weighting procedures of the assessment. Consistency is essential as the assessment method cannot be reliable if one significant variable greatly skewed the results one way or another. However, if the results are too consistent, one can argue that there is no significance in the assessment method, and the results can only be affected by extreme cases. Inconsistency is important, as argued by Saaty, 1987, for '*without it new knowledge which changes preference order cannot be admitted. Assuming all knowledge to be consistent contradicts experience, which requires continued adjustment in understanding.*'

Three significant variables were changed from the functional inventory scoring and the priority weights, and the new results recorded. The percentage changes are calculated, it was decided that new results should be between 5% to 20% of the original to establish that the method is consistent. The range was decided to be more than 10%, as there are a large number of variables within the assessment. The results of the sensitivity analysis are showed in Table 8-10. it is important to know that for the priority weights variable, the other priority weights were altered proportionately for the analysis. All the results fall within the desired range of consistency, and therefore the assessment method can be accepted as consistent, and the major variables will not affect the results too greatly.

Table 8-10 Sensitivity analysis results

		Original Score	Test Score	Original SBA Result	New SBA result	% Change
Functional Inventory	Sensory	6	3	41%	34%	17%
	Physical	7	4	41%	36%	12%
	Mental	2	8	41%	46%	12%
Priority Weights	Sensory	28%	58%	41%	46%	12%
	Physical	21%	51%	41%	44%	7%
	Mental	41%	41%	41%	36%	12%

8.3.4 Interpretation

Toy B has much better results in sensory stimulation and both fine and gross motor development. This can be attributed to the integration of electronic music units in the soft toy. In general, the addition of electronic parts has enhanced play and it is certainly a common trend in the industry. This is also the same case for preschool toys that depend heavily on sensory stimulations, and electronics parts have definitely enhanced the sensory stimulations. However, previous LCA studies on musical teddy bear concluded that the environmental impact of the battery operated toy is far higher than without (Muñoz et al., 2008). Therefore, results should be considered in a holistic way and further decisions should be considered along with economic and environmental assessment results for a holistic sustainable strategy. Furthermore, the assessment could be carried out for a second time where the targeted user groups are older, thus the importance weighting would be recalculated. This will help establish the validity of the assessment.

8.4 Summary

This chapter described the design and implementation of a method for implementing the SBA framework. It justified the selection of toys as the focus for the method development and demonstrate its application. It also presented the play type of toys that are being assessed as the functional inventories, the AHP pairwise comparison method that is applied to establish the importance weighting, and the method to classify and characterise the functional inventories into benefit scores. The next chapter will present a toolkit that aims to integrate these methods into for a broader sustainability and resilience strategy for toy manufacturers.

Chapter 9 Strategic Management Toolkit for Sustainable Product Management and Design

9.1 Introduction

The previous chapter presented the SBA method. This chapter present an integrated toolkit for sustainable toy management and design. The chapter begins by explaining the reasoning behind the toolkit and how the SBA method fits into a bigger sustainable product management and design picture. The chapter continues by describing the design and structure of the toolkit. The toolkit follows conventional three-stage management approach, with set sequential steps for each of the three stages. Along with SBA, other methods and tools are also identified and selected to be used in the toolkit. The chapter also describes the tools that are utilised in this toolkit, a Cost Benefit Matrix tool is also proposed. Cost Benefit Matrix is a tool that is developed to integrate environmental assessment results with SBA results for strategic management support.

9.2 The Need for a Strategic Management Toolkit

The SBA method was demonstrated through the example of the assessment and comparison of two toys, the societal benefits scores provided insight into redesigning toys with a benefit focused. However, the social perspective is not and should not be the only factor considered by sustainable manufacturer. A holistically sustainable approach that considers economic, environmental, and social factors is required. The strategic management toolkit presented in this chapter demonstrates how SBA fit into this wider sustainable context. The toolkit ensures clear translation of sustainable strategies from top level management to operational level product design activities. It can identify tools and methods that are needed to assess the sustainable performances of the products, and the information and legal requirements that are needed for setting sustainable business goals and aims for products.

9.3 The Integrated Toolkit

The basic structure of the toolkit follows traditional three-stage set up of strategic management; it consists of strategic, tactical and operational stages. Businesses stay competitive by delivering unique values to customers. Strategy is the provides the overall aim to do that; it deals with what needs to be done to achieve a goal based on current situations and future forecast. Tactic plans out how the goal is achieved, and the operation is the action carried out according to the tactic. This approach has a clear hierarchy and communication structure. The toolkit is initially designed for supporting strategic management for one product, however manufacturers' businesses have multiple products and brands and sometimes multiple lines of business. This is referred to be different levels of business complexity. The toolkit consists of three levels of business complexity: corporate, brand, and product level. Product level is the lowest level, where individual products are considered. Brand level is where several products are grouped together as one brand, and corporate level is where these brands are grouped together as one whole business. The results from the higher levels can be used for the lower levels input, conversely, the outcomes from the lower levels can be used to inform decisions in higher levels. The toolkit takes the shape of a three by three grid with connecting flows from stage to stage and from one level of business complexity to another, as show in Figure 9-1.

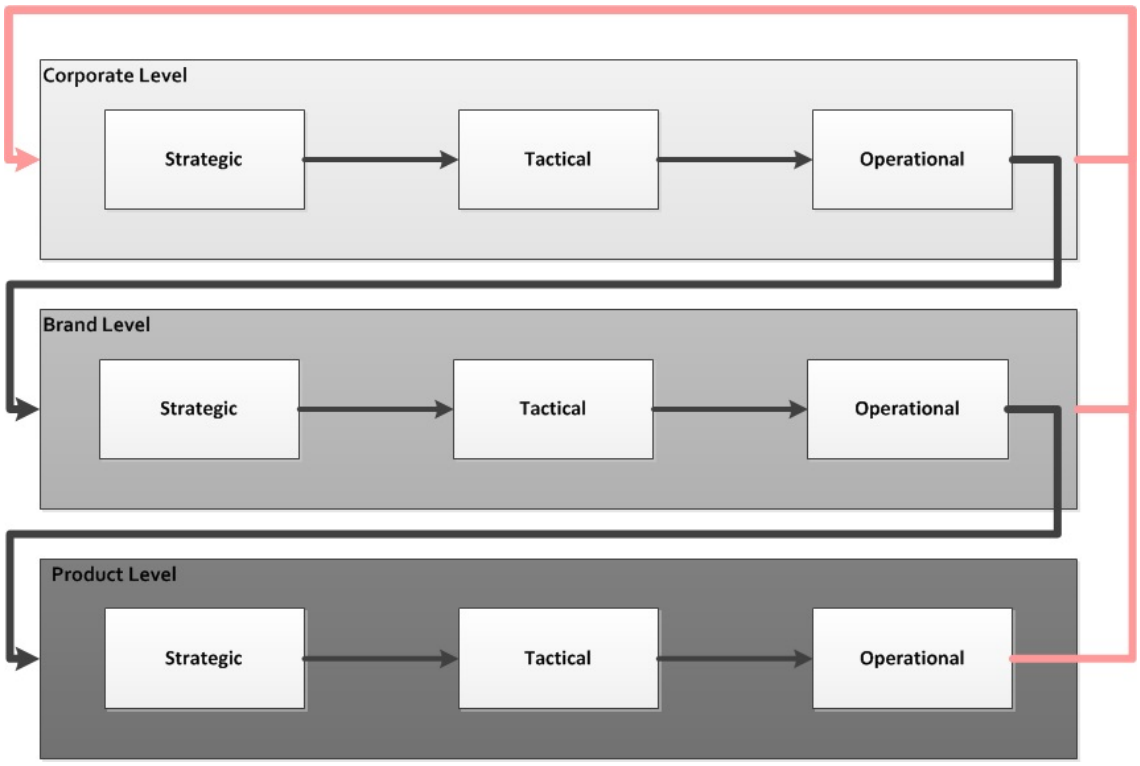

Figure 9-1 Three stage toolkit at three different level of business complexity

It is envisioned that an organisation would enter the toolkit at its relevant level of complexity. The organization would follow the sequential stages running horizontally. At the higher levels of complexity, it is the groupings that are considered and not individual products. therefore, information used will be more qualitative and general rather than quantitative and specific for the lower levels. By starting at the higher levels, the business is able to quickly identify those parts of the business that required to be prioritized. These groups will then be addressed at the next level of lower complexity. This process can also be carried out at each level as a stand-alone activity or be repeated in the lower complexity level all the way to the product level. As shown in figure 9-1, outputs from the lower levels can be fed back to the higher levels as an iterative process that ensures continuous improvement, which in turn improve accuracy.

The stages of the toolkit at the product level are now discussed in more detail but the same principles apply to the previous higher levels. The overall aim of the toolkit is to support sustainable strategy, it is illustrated in Figure 9-2. The toolkit input and output are presented as IDEF0 diagrams, the advantages of using IDEF0 diagrams is that it clearly highlights the requirements and corresponding mechanisms for each process box as well as the input and output. Requirements are represented by arrows going into the boxes from the top (e.g. Legal Requirements and supporting information). Mechanisms are represented by arrows going into the boxes from the bottom (e.g. methods and tools required for the process). Thus, the data required and information feeding out of each process are clearly defined and indicated.

Figure 9-3 shows the expanded system of the overall single level toolkit at product level. It clearly demonstrated the three stages of the tool: Strategic positioning, Tactical planning and operational design. The pre-defined organisation strategy is fed into the first stage as input into this tool. The first stage is strategic positioning, and the outputs are performance targets. These targets are fed into the tactical planning stage where design briefs are outlined. And finally, the design briefs are used by product designers to redesign the products.

9.3.1 Stage One – Strategic Positioning

The aim of this stage is to establish the strategies set in previous levels into relevant strategic targets of products groups, support the translation and communication of strategic targets into

plans and actions for later stages. Traditionally strategic targets have been relatively straightforward to communicate in economic terms. However, the traditional system proves to be less adequate in communication of less conventional strategies such as environmental performances, social responsibilities, social values and knowledge. Long term strategic targets are becoming increasingly difficult to be represented in simple financial measures, other methods and sustainability indicators should be developed and considered. The intention of this stage is to address these issues by identifying, organising, and quantifying specialist knowledge into social and environmental impacts for a fair assessment to acquire actionable results. The assessment itself will be the main activity of this stage.

Figure 9-2 Overall toolkit input and output in IDef0 format

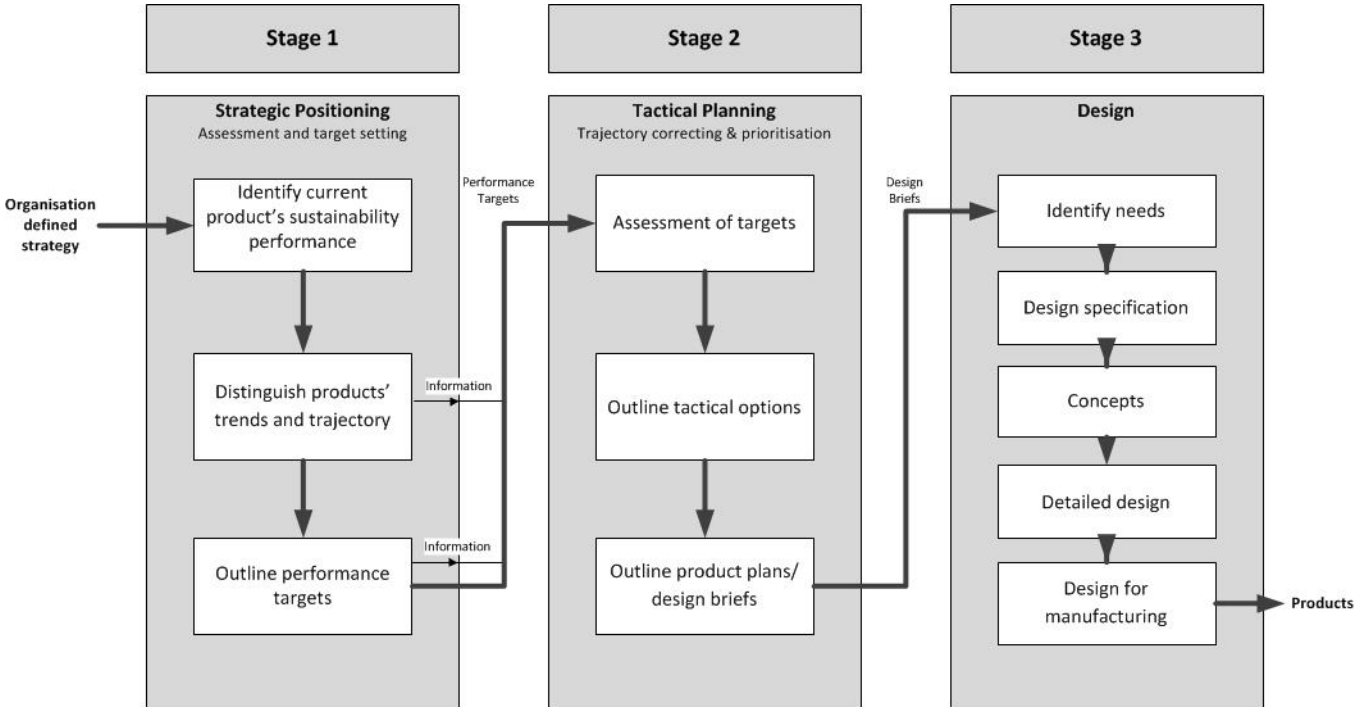

Figure 9-3 Expanded system of the overall single level toolkit at product level

Stage one of the toolkit aims to answer three strategic questions about the product(s) considered. The results will aid the determination of the targets that will set the directions for the entire manufacturing company. The three questions are: "How is/are the product(s) performing in terms of the social and environmental sustainability?", "What are the products' future performances?" and "How should the products be doing in the future?"

There are three steps in this stage of the toolkit which are set up to answer these questions and to develop a clear set of targets and goals for the subsequent tactical planning stage. The three steps in the strategic planning are as follow:

1. Current Products' Performance Assessment
2. Products' Trends & Trajectory Analysis
3. Performance Targets Formulation

Figure 9-4 shows the process flow of the strategic positioning stage. It illustrates the steps with the corresponding methodologies and requirement (arrows pointing down towards processes) in IDef0 format.

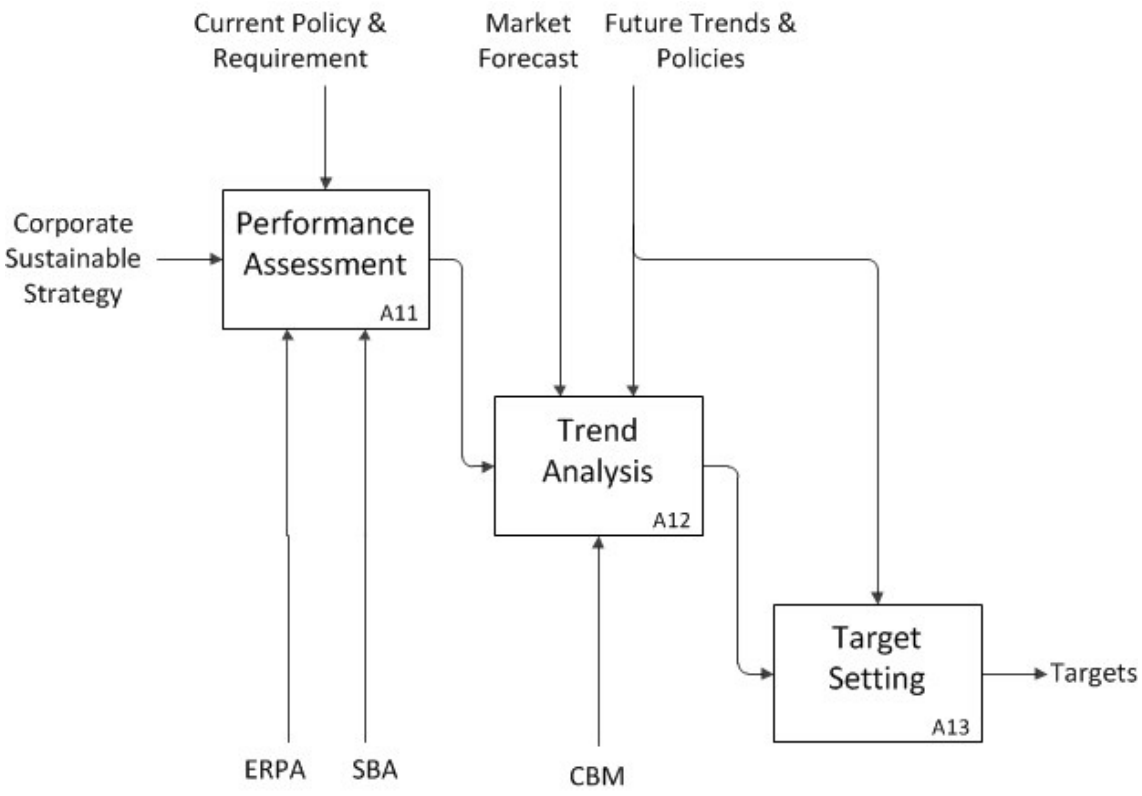

Figure 9-4 Process flow of the strategic positioning stage

9.3.1.1 Step one - Current Products' Performance Assessment

The first step is the identification of sustainability performance of products. This consist of aligning the sustainable performance assessment with the company overall strategies. Once the strategies are clearly stated and the boundary of assessment for sustainable performances of products is set, the actual assessments can take place. Two methodologies are adopted for this step; Environmental Responsible Product Assessment (ERPA) is used for assessing the environmental performance while SBA is applied for the social performances. The details and mechanisms of these two methodologies will be demonstrated in a case study that is carried out for this research in the next chapter. The results from these two assessments will be normalised into a single score for integration into the main positioning tool.

9.3.1.1.1 Cost Benefit Matrix

A strategic positioning tool called Cost Benefit Matrix (CBM) for the integration and presentation of the results from ERPA and SBA, this is illustrated in Figure 9-5. CBM

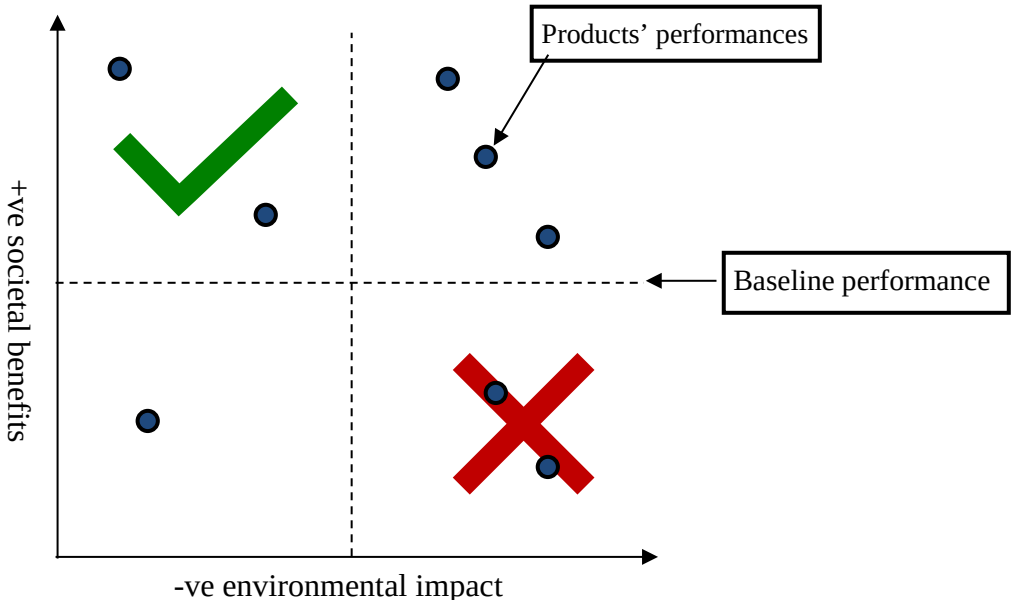

Figure 9-5 Cost Benefit Matrix

essentially plots each product's environmental and social performances onto a graph. The x axis represents the environmental performance in a single score form, the y axis represents the societal benefits factor, which is determined from the applying SBA. The products' performances are plotted onto the graph, this visualises the performances and makes it more accessible to compare performances. A matrix can be set up by benchmark performances or strategic targets for both environmental and societal performances; this can be seen as the dash lines in figure 9-5. These targets are set by the practitioners who are carrying out the assessments. In the case of a toy company, these will the predetermined strategic goals in the form of environmental and societal benchmark performances.

9.3.1.2 Step two - Distinguish product's trends & trajectory

Forecasting methodologies can be applied in order to determine the future social and environmental performances of the products. Marketing information like key trends can also be used to adjust the future performances for a more accurate prediction. The results can be plotted onto the CBM matrix.

9.3.1.3 Step three - Outline performance targets

New targets are set for future products (re)development. These targets are set based on information of future legislative requirements and expectations for improvements both socially and environmentally. The targets will also be plotted on the CBM matrix. Data from all three

steps will all be plotted onto the CBM matrix so that they can be visualised and compared in order to have a provisional understanding of time and actions required to achieve the new targets.

9.3.2 Stage Two – Tactical Planning

The second stage of the toolkit is the correction in trajectory and prioritising. From the previous stage, the strategic positions and trajectory were determined to aid the planning of actions to meet the targets set. The main output of this stage is the development and delivery of design briefs to the next and final stage. The overall processes are illustrated in Figure 9-6. The design briefs must contain all the marketing information, requirements and customer needs for a fully informed design process and specification formulation in the design stage following. There should also be information on time, cost and human resources as to how and when the design should be finished and pass on to manufacturing. In order to develop these design briefs, three steps are devised to ensure the complete and thorough translation of strategic targets into design briefs:

1. Targets assessment
2. Outline tactical options
3. Draft design Brief

9.3.2.1 Step one - Targets assessment

The targets set in the strategic planning stage provides targets to be achieved, however there are no indications of timing and priorities when multiple products are involved in the decision-making process. There are multiple products and product lines in even medium toy companies, and it is essential to determine priorities and time scale along with the targets for sustainability performances. This is because of the fast and unpredictable nature of the toy industry and its market trends.

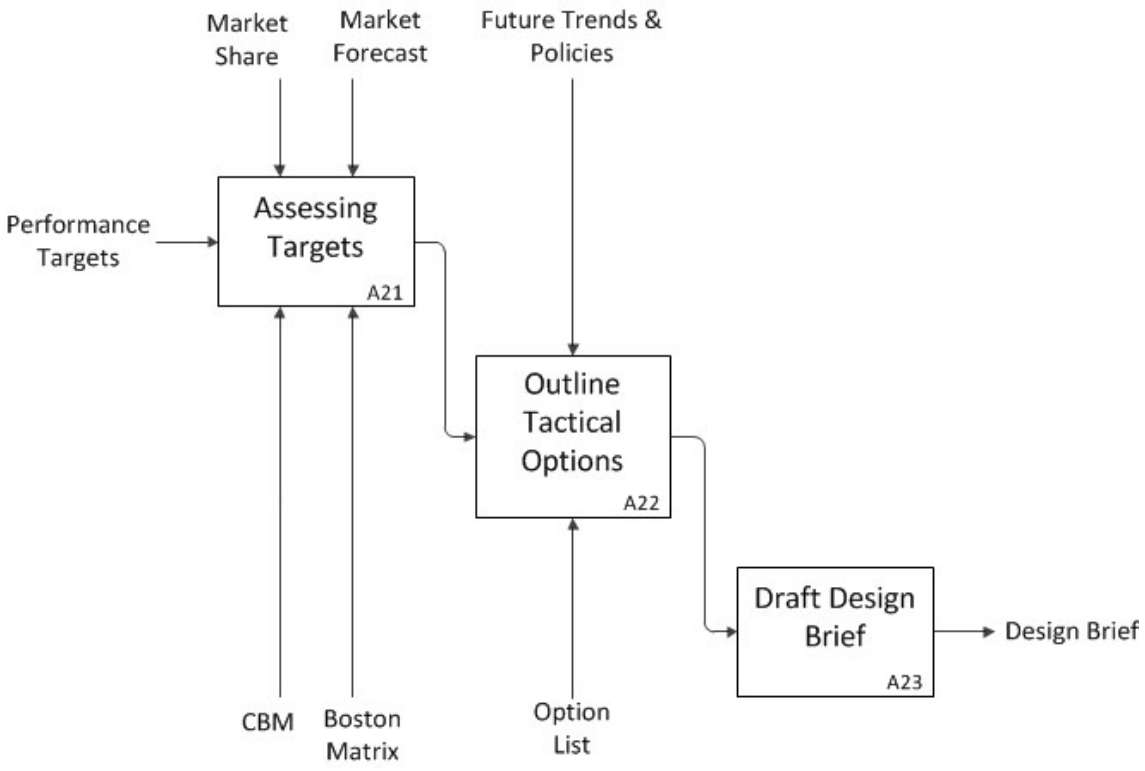

Figure 9-6 Process flow of the tactical planning stage

In order to determine time scale and priorities, CBM and a Boston matrix are used for visualising and comparing the products on both matrices. The Boston matrix is a widely used and well-established tool that is used by manufacturing companies for managing their product market life cycle, i.e. the products' life in the market. It is not to be confused with the actual products' use life cycle that is interpreted in LCA. The Boston matrix measures market growth and market share of products, it effectively divided the plotted graph into a four-quadrant matrix with four combinations of market growth and market share. Cash cows are products that have a high market share but a slow market growth. Stars are products that have high market share and fast market growth. Dogs are products that have low market share and low market growth, indicating a fading product. Question marks are products that have high market growth but low market share, which is normally seen as problematic and required considerate decisions for further actions.

9.3.2.2 Step two - Outline tactical options

The second step intends to outline all the available options for each product or product group. CBM presents visualisation of the environmental and social performances, whilst the Boston matrix provides indication of priorities and timing for any further actions. The Boston matrix

give the targets importance and determine whether actions should be taken quickly or simply terminate sales and manufacturing of some products. For instance, a product that is low in market share and market growth should not have any resource committed for redesign as there is no future for the products. Conversely, actions should be quickly taken for products that are cash cows and rising stars as the any slow action may have huge impact to the business. Depending on the determined targets of each product from the previous step, a tactical option will be assigned to the product or product group.

9.3.2.2.1 Tactical Options

A list of tactical options was drafted for companies to follow. In general, targets are achieved with three main goals: to improve economic sustainability, to enhance positive social benefits, and to reduce negative environmental detriments. In order to achieve these goals, nine tactical options are identified, they can be grouped as either internal or external activities. The options are listed in Table 9-1. These options are formed out of a combination of sustainable design strategies and conventional product life cycle management strategies (Labuschagne and Brent, 2005; Levitt, 1965).

The external options are entirely economic activities, they aim to replace products and brands that do not fit with the strategic targets, in present and future, with products that are external to the company that have huge potentials. One of these options is to acquire, this may be in the form of company takeover or just a limited number products and product groups along with their associated intellectual properties. Companies will need to understand their competitors and the availability of these products.

Table 9-1 List of tactical options showing the sustainable areas covers

	Tactical Options	Sustainable Area		
		Env.	Soc.	Econ.
Internal	Maintain			✓
	Pause sales			✓
	Reduce sales			✓
	Terminate sales			✓
	Improve design	✓	✓	
	New product development	✓	✓	
External	Acquire rights			✓
	Sell rights			✓
	Trade rights			✓

Another external option may be to sell off products that do not fit with the strategic targets. Products and brands that may not fit with the strategic targets in short and medium term future may still have value in the market, instead of completely terminating the product market life, it may be appropriate to gain financial returns from products that are successful. The third external option is in essence a mixture of the first two. Trading may involve a tactical swap of brands and products with other companies. It may also be a transfer of ownership to a subcontractor or vice versa.

The first four internal tactical options are economic activities while the last two are mainly a mixture of environmental and social actions. They aim to steer/redirect the products towards the performance targets that were set. The first option is to maintain current activities. If the products are already performing to the targeted goals or the future developments are heading towards that direction, then there is no need to change. Therefore, all activities should be maintained. Products that may require action later but at a lower priority may also be maintained. However, it is important to oversee any developments to ensure they are developing to the correct directions. The second option is to pause/ hold marketing and sales. There can be a number of factors that contribute to the marketing and sales activities of certain products to be held. Generally, the products that will be held may not be suitable to be sold in the market, but it may have high value or potential in the future.

The second and third tactical options are effectively exit strategies. When the trajectories of products are not going to towards the targets and the values of products are low, there might be a need to end these products' lives. In ending the sales of these products, there are two options; the company can reduce sales and slowly phase out the product or sales can be terminated entirely.

Lastly there are two options that require other activities other than economic decisions. These involve setting briefs for the design team. The main objective for these two options is to create value, and open up new ideas. The first option is to improve existing products and brands. The main objective of improving the products is to reduce the inherent sustainable detriments of the products and also to enhance their benefits to the users. This can be achieved in a combination of two ways; the products and brands can be rebranded and the products can also be redesigned. In regard to rebranding, it aims to redirect the products to more suitable consumers so that their function will more suitably accommodate the users, thus enhancing the benefits to the users and to greater society.

On the other hand, products can be redesigned to reduce their detriments. Different aspects of the brands can be redesigned: process, products, service and supply chains. The products can be redesigned to utilise newer, more efficient manufacturing process. The products can be redevised with newer materials and less materials so that it's more environmentally friendly. The supply chain and services can be re-established to reduce environmental damages while providing more personal services. Product service system can be implemented where a combination of products, services can be redesigned and repurposed along with their supply chains. The same considerations will be contemplated for new product development where new products and brands are required to be created to improve companies' profile and expand products portfolio.

9.3.2.2.2 Determining Tactical Options

A table of tactical options in relations to the combination of targets and Boston matrix positions are produced (Table 9-2). The tactical options were covered in the previous framework chapters, there are marketing options as well as redesign options that may results in improvements in both societal benefits and environmental impacts reduction. For the Boston matrix, rising stars are labelled as 1, cash cow as 2, question mark as 3 and dog 4. For the CBM, A represents where there is high societal benefit and low environmental impact, B represents where societal benefits are low and environmental impacts are low. C represents where there is high societal benefit but a high environmental impact and D as where societal benefits are low and environmental impacts are high. These are illustrated in Figure 9-7. The determination of tactical options is based on conventional product life cycle management strategies (Lambkin and Day, 1989; Levitt, 1965). These decisions are determined by several factors on top of market growth and market share, such as competitors pressure, profit squeeze potential, and life extension potential (Labuschagne and Brent, 2005; Stark, 2015).

Table 9-2 Tactical options for CBM and Boston matrix results combination

CBM results	Boston matrix results	Tactical options
A	1	Maintain status quo
A	2	Maintain status quo
A	3	Improve Design, Pause sales for later decision
A	4	Terminate sales, Develop new products, Reduce sales, trade rights
B	1	Improve design for societal benefits, Maintain status quo
B	2	Improve design for societal benefits, Maintain status quo, Develop new products
B	3	Improve design for societal benefits, Pause sales for later decisions, Trade rights
B	4	Terminate sales, Develop new products, Acquire new product line, Sell rights
C	1	Improve design for environmental design, Maintain status quo
C	2	Improve design for environmental design, Maintain status quo, Develop new products
C	3	Improve design for environmental design, Pause sales for later decisions, Trade rights
C	4	Terminate sales, Develop new products, Acquire new product line, Sell rights
D	1	Improve overall design
D	2	Maintain status quo, Develop new products
D	3	Pause Sales, Develop new products, Reduce sales, Sell rights
D	4	Terminate sales, Develop new products, Acquire new design rights

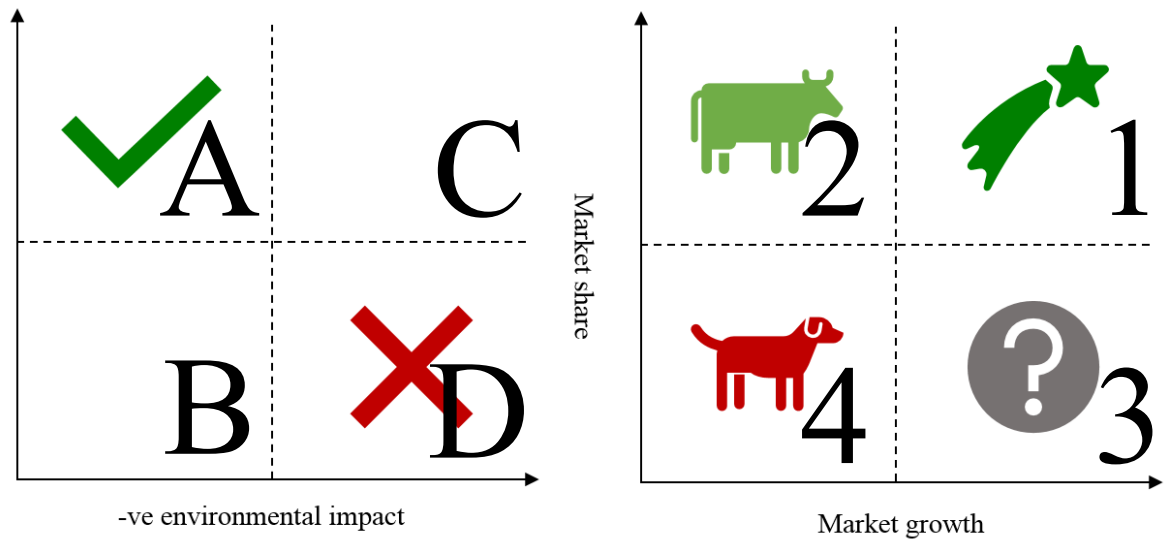

Figure 9-7 Labels for the quadrants of CBM and Boston matrix

9.3.2.3 Step three- Outlining design brief

For redesigning options, a design brief should be generated for toy designers are manufacture engineers to follow. The brief should be a clear statement that is instructive for achieving targets, however it should not be specific so that there are rooms for creativity and innovation. The design brief should embody the targets that were set in strategic phase and should have clear indication of what to achieve. It will be evaluated with a streamline CBM that briefly plots the performances. This step is performed to ensure accurate translation of strategies and targets from top to bottom.

9.3.3 Stage Three – Operational Design

The operational design stage only applies to where design or redesigning was selected as the tactical options. The processes involved are depicted in Figure 9-8, along with the methods, tools and information that are required for each stage. The toy design process follows a well-established, wildly used methodology of design; it starts with identifying needs and formulating a specification for the design where the needs are fulfilled. In this case, societal benefits will ne highlighted as one of the more important needs. CBM can be used to quickly assess the specification to see whether the product described in the specification is going to perform to the brief drafted in the tactical stage and the targets set in the strategic stage. Design concepts are generated in accordance to the specification, where detailed design and prototypes are made. QFD methodology can be applied to ensure that the specification answers all the needs

listed. Once again, the concepts, detailed design and prototypes can all be measured in CBM to ensure the social and environmental elements are properly and thoroughly considered. The final design put forward for manufacturing can be evaluated with performance data and put into CBM for a detailed assessment to confirm whether the final products are performing to the targets set in the strategic stage.

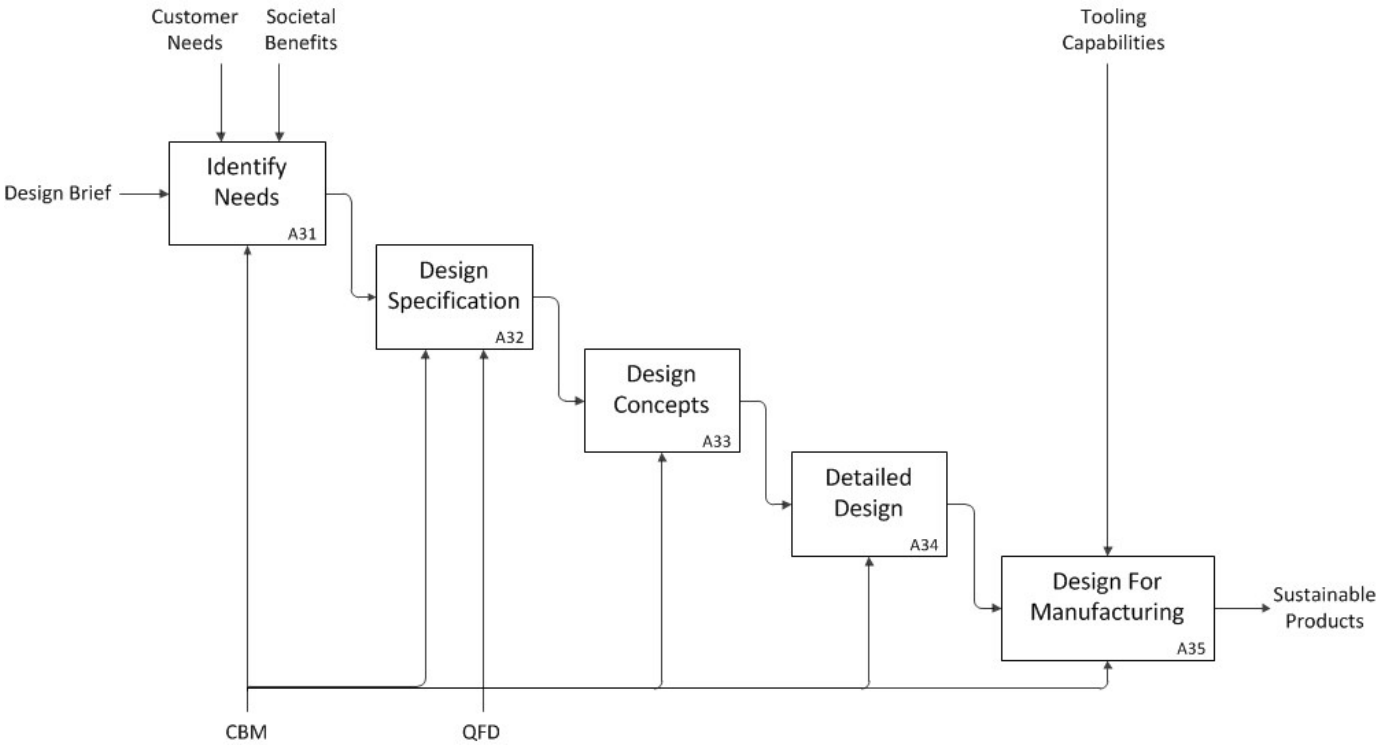

Figure 9-8 Process flow of the operational design stage

9.4 Chapter Summary

This chapter presented the integrated toolkit for sustainable product management and design. The chapter provided the rationale for an integrated toolkit with a holistic sustainable approach where all three pillars are considered. The structure of the toolkit was presented, the repeatability of the toolkit for different levels of business complexity was also explained. The three stages of the toolkit were described in detail. The steps that were involved in each stage were explained, tools and methods were identified for these steps. CBM was presented as a tool to integrate and visualise environmental and SBA performances of products. Next chapter of this thesis provides two case studies which aim to exemplify the use of SBA and the integrated toolkit and how two toy companies can utilise this toolkit at two different levels of business complexity.

Chapter 10 Case Studies

10.1 Introduction

This chapter discusses two case studies that have been used to demonstrate the applicability of research concepts related to TOYSBA and the integrated toolkit described in previous chapters. This chapter begins by providing an overview of these two case studies, both of which looking at the social and environmental performance of toys. The first case study is based on a Hong Kong based SME toy manufacturers. The second case study is based on a mega-corporation and its global toy brand for pre-school children, similar to Mattel's Fisher Price or Lego's Duplo.

10.2 Description of the Case Studies

Due to the confidential nature of the type of information used in this process, fictitious companies were formulated from information sources obtained from companies that fit the case study profiles. It was possible to base the case study on real word data by combining the information gathered. Any additional information required will be generated as part of the simulation process. By using the decision support tool, the two companies' toys will be evaluated. The key aims of the two case studies are:

- To demonstrate the practical use of the decision support tool.
- To compare the outcome of two toy companies at different business complexity levels.
- To substantiate the effectiveness of the tool in meeting the original research aims and objectives.

10.3 Case study A – Fullplay Ltd

Fullplay ltd. is a national, SME with a small product portfolio of wooden pre-school learning toys. Fullplay is based in the UK; all business and manufacturing activities are carried out in the UK from design to distribution. This is due to the small batches of orders and a tighter

control on qualities. Whilst not a market leader, it is well known within Europe and has a steady following from online parenting communities. Unlike other some other toy manufacturers, Fullplay solely focus on its own products instead of licensing with other global toy companies, films and cartoons.

The information used in this case study has been combined from publicly available data on companies with similar profiles to that of the fictional Fullplay Ltd. Where information required for the study was unavailable from either of these companies, simulated data based on general market trends was used. The relevant data obtained from published literature is presented in Table 10-1. Extracts from key data sources used to compile this table are included in Appendix 5.

Table 10-1 Fullplay ltd company facts with 'real world' comparisons. Sources: (HKTDC, 2017; Playmates Toys Inc., 2016)

Company Information	Fullplay ltd.	Playmate Toys Inc	Chap Mei Plastic Toys Mfy. Ltd.
Established	1980	1966	1971
Markets	UK	UK and US focused	UK and US focused
HQ	Fleetwood, UK	Hong Kong	Hong Kong
Corporate mission	We play, we educate	We deliver high quality, safe, and innovative toys	We love toys. We make toys.
Marketing Approach	Original	Licensing	Original
Number of Employees (HQ)	40	71	50
CSR report	In Annual Report	In Annual Report	N/A
Environmental effort	Reduce materials	Reduce materials	Reduce materials
	Energy Saving	Reduce packaging	Reuse materials
	Recycling	Replace toxic and environmentally unfriendly materials	Replace toxic and environmentally unfriendly materials
		Improve Transport	
Social Effort	Workplace Safety	Improve Working practices	Improve Working practices
	Responsible Sourcing	Improve ethical and responsible conduct	Improve ethical and responsible conduct
	Ethnic Equality	Maintain health and safety standards	Maintain health and safety standards
	Gender Equality	Encourage volunteering	

By definition, SMEs have a smaller pool of resources to draw on. Usually this access to resources plays key influence in the decision-making process at both strategic and operational level. Recognition of the importance of resources at the SME level led to the development of resource-based theory and its sustainability as a methodology for executives and owners (Rangone, 1999). Rangones's proposed a model that SMEs' competitive advantages are based on three basic capabilities: Innovation, Production and Market Management. Almost all SMEs consciously or unconsciously put their strategic focus on one or more of these capabilities.

Toy SMEs tends to have three main options for access to market; licensing for popular brands, in-house designed toys and a mixture of both. They tend to focus in their specific market sector. For instance, Chap Mei Plastic Toys Mfy Ltd has been developing its own brand of action figures for the last 40 years, while Playmates Inc. focuses mainly in licensing with Teenage Mutant Ninja Turtle being a prime example. Conventionally, licensing is a preferable option in the UK, as a Unicef reports pointed out that the UK market has a lower expectations of toy functionality, education experience, and the quality of the play experience (UNICEF, 2011). This implies that popular brands and characters would have an easier access to markets and a greater year 1 sale regardless. However, increasing sales of electronic toys and video consoles meant that the market is tighter and more competitive.

There are little to no evidence in any form of corporate social responsibility schemes, as toy SMEs run on a very tight profit margin and focus in their strategic capabilities that were mentioned earlier. However, companies are more aware of the importance of green/ethical practise and labelling because of the growth in internet shopping and online parenting communities.

10.3.1 Strategic Aim

Similarly, Fullplay Ltd designed and manufactured its own brand of infant and preschool toys. This category of toys takes up roughly 12% of the market. Its aim is to design and manufacture fun, exciting and educational toys for preschool children and infants. Due to the threat of the emergence of young children electronic tablets and increasing demands and inquiries about its toys' education experience and "green" credentials, Fullplay is aiming to increase marketing exposure of its toys' beneficial value for children development, and identify improvements opportunities in future products development.

10.3.2 Strategic Objectives

In order to achieve the strategic aim of Fullplay, three objectives are formulated:

- To assess the overall sustainable performances of its products against its competitors'.
- To identify opportunities for design improvements.
- To improve products for competing with major rivals.

10.3.3 Product Level Tool

One of the most popular toys designed and manufactured by Fullplay is the wooden sensory blocks for 12 months to 2 years old children. It consists of a few colourful boxes filled with coloured beads and balls. It allows children to sort them, stack them and making different sounds and noise with them. The hollow boxes allow children to look through and see a world with different colours. These blocks should engage the children and develop basic ideas like shapes, colour and sound recognition. They would encourage fine motor skill development and creativities. This toy is assessed with the tool along with 6 other identified competitors'.

10.3.3.1 Strategic Positioning

10.3.3.1.1 SBA

The play type score for each of the toys are filled into a form. The scores are adjusted with the importance scores that were calculated before. The play type scores for Fullplay's sensory blocks are illustrated in Figure 10-1. The scores were weighted according to the pairwise comparison weighing priorities through the use of AHP with expert inputs. The scores were classified and categorised into benefits scores. The benefit scores are listed on Figure 10-2.

10.3.3.1.2 ERPA

For environmental impacts, a fully detailed LCA was not available, due to the unavailability of data required. Therefore, environmentally responsible product assessment (ERPA) was used instead. This method enables a quick and clear assessment with the limited data (Hochschorner, 2003). The method relies upon the expertise of the groups in sustainability, materials, and supply chain knowledge. The five chosen impact categories are resource depletion, greenhouse gas emission, eutrophication, water used, and harmful substance emission. Some of the categories descriptions are deliberately widen for the group of experts in the exercise, because

Product Name Fullplay Colourful Sound Sensory Blocks	Score	Adj Scores
Sensory	9	9.00
Construction	6	3.04
Challenge	3	0.64
Fantasy	0	0.00
Social Play	2	0.10
Solitary Play	7	0.86
Free Play	10	3.15
Play with Rules	5	0.45
Mental	4	1.56
Physical	4	2.94
Product Description		
It consists of a few colourful boxes filled with coloured beads and balls. It allows children to sort them, stack them and making different sounds and noise with them. The hollow boxes allow children to look through and see a world with different colours. These blocks should engage the children and develop basic ideas like shapes, colour and sound recognition. They would encourage fine motor skill development and creativities. This toy is assessed through the tool along with other identified competitors'.		
Intended age	12 months to 2 yrs	

Figure 10-1 Play type scoring for Fullplay sensory blocks

of the lack of exact data. For the ERPA, 0 is set for the worst impact and 4 is set to be performing well environmentally.

Amongst the toys that were assessed, there were a range of toys for two to three years old. There were a battery-operated singing and dancing soft toy, a sensory play table with lights and buttons, a pull along toy that has lights and small parts, a plastic animal play set, a book with buttons that make noise of the corresponding animals and a toy car play set. The key differences in life cycle practises are as follow. The wooden sensory blocks sourced their materials within Europe and does not require shipping, whereas the other two toys have a global

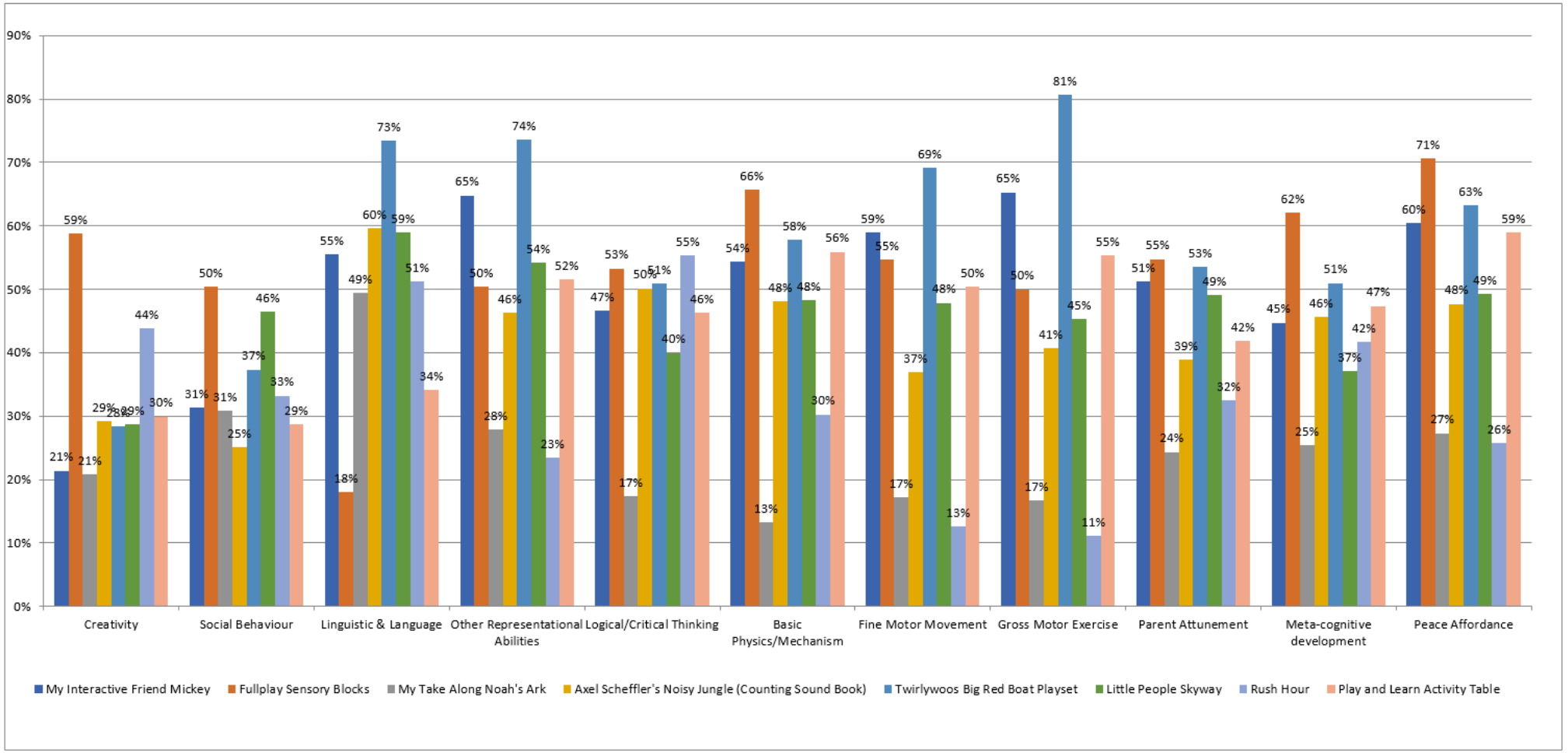

Figure 10-2 Benefit scores of toys assessed

presence, and therefore required shipping. This drastically increase the transport related impact as it is known that global toy companies with their own shipping containers send empty container back to where the toys are manufactured (Muñoz et al., 2008). The wooden toy is also the only toy in this exercise where batteries are not required. The usage scenarios for the singing and dancing soft toy and the pull-along toy are the same; the toy would be used for roughly two years, for two hours a day. That is estimated to be roughly 39 AA batteries per toy for that period. The results chart from the ERPA of the sensory blocks is illustrated in Figure 10-3. It was clear that the absence of the use of batteries and a localised supply network has contributed to much of the environmental advantages of the wooden sensory blocks.

Fullplay Sensory Blocks	**Impacts**					
Life Cycle Stages	RD	GHG	EU	WU	HSE	Impact score on each stage
Raw Material Extraction	3	4	2	2	3	14
Manufacturing	4	3	4	4	3	18
Transport	3	2	4	3	2	14
Use	4	4	4	4	4	20
End of Life	4	3	4	4	4	19
Impact score across LC	18	16	18	17	16	85

RD	Resource Depletion
GHG	Green House Gas Emission
EU	Energy Use
WU	Water Use
HSE	Harmful Substance Emission

Figure 10-3 ERPA scores for fullplay's sensory blocks

10.3.3.1.3 CBM

The results of both SBA and ERPA are combined and plotted onto the cost benefit matrix, Figure 10-4. the performance benchmarks are set at 60 for the environmental impacts and 50% for the societal benefits. Out of the seven toys, the counting sound book and the sensory play table fall into the underperform quadrants. The plastic animal playset and the toy car play set are performing well environmentally and underperforming in societal benefits. The singing and dancing soft toy, the pull along playset and Fullplay's sensory blocks are all performing well environmentally and socially. The sensory blocks have an environmental advantage over all the other competitors, because it does not require batteries and it has a national supply network.

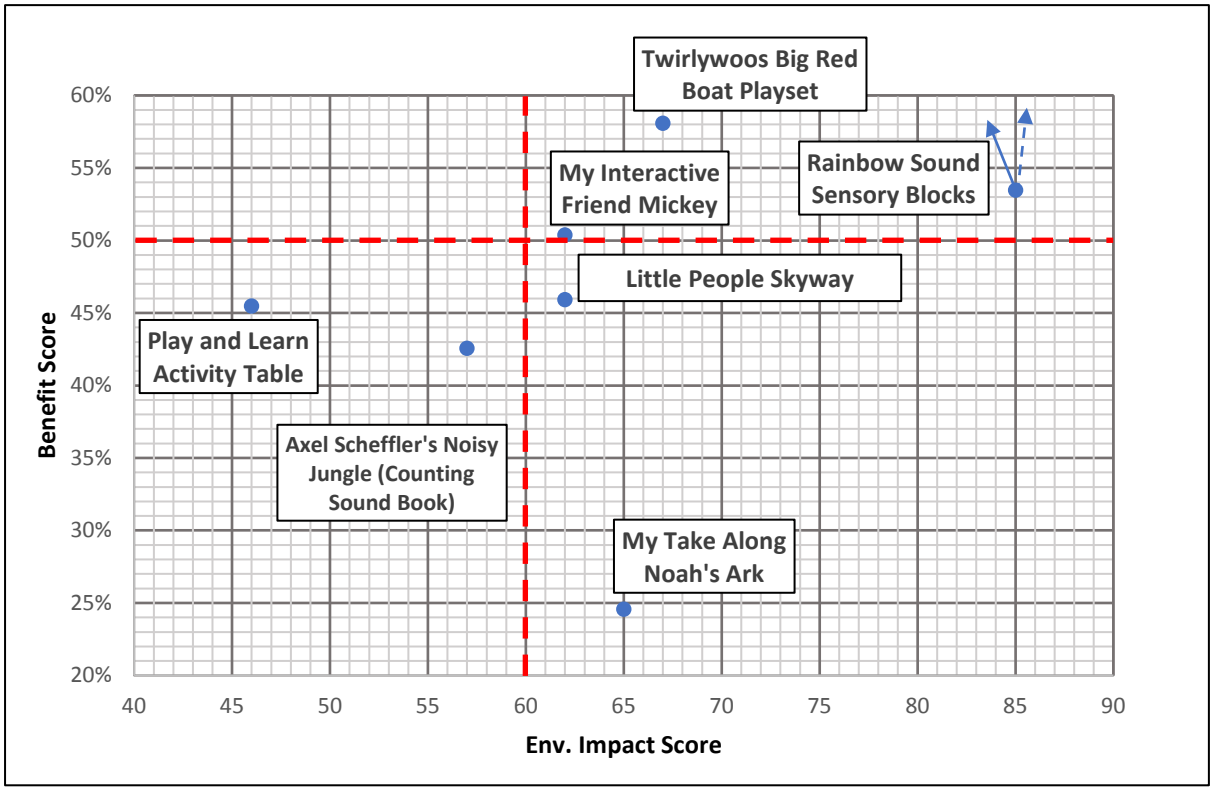

Figure 10-4 CBM plotting performances of all the toy assessed

10.3.3.1.4 Trends and targets

The trend and target for Fullplay is set and plotted onto figure 10-4: performance trend is presented as solid arrow, while dashed arrow represents the target. The performance trends indicate that current existing development in design will bring the toys down in terms of environmental. This is because of the possibility of incorporating flashing electronic lights into the existing design. The target is set with the urgency and priority in mind. The sensory blocks are performing well environmentally, therefore their targets all show to be pushing towards improving the societal benefits.

10.3.3.2 Targets assessment

The target is assessed in perspective of their market growth and market share as well. The sensory blocks have low market share due to its niche market, but it has shown a good and steady market growth because of the increasing popularity amon*gst parenting social* websites and increased general awareness of environmentally friendly toys. This would make it a question mark in the Boston Matrix. Tactical options were highlighted from putting the results of Boston matrix and the cost benefit matrix together. From which it was concluded that It would be sensible to improve its design for societal benefits.

10.3.3.3 Design brief

Design briefs should be set for toy designers within the companies. For the Fullplay's sensory blocks, societal beneficial features need to be added or enhanced. This would mean design aims for the toys. The pairwise comparisons results can be used as a guide. And that means improving the designs in the sensory and physical play types mostly and features that would provide constructive play opportunities.

10.3.3.4 Design specification

A product design specification is drafted for the redesign for Fullplay's sensory blocks in Table 10-2.

Table 10-2 Product Design Specification for Fullplay Sensory Blocks redesign

Fullplay Sensory Blocks	Product Design Specification
Purpose	CBM strategic support tool results and TOYSBA results indicated That constructive and physical play should be enhanced for better early childhood development benefits.
Features	General product description: Hollow wooden blocks of various geometric shapes. Blocks have different coloured translucent cover with different rattles, beads, and bells inside. Extra features: - Flashing lights - Mirror surface - Interesting texture for fingers - Joining interfaces for easier constructive play
Intended Market	The intended users of the toys are children between the age of 2- 4 years old. However, the buyer of the toys would be adults and most likely to be parents who are more aware of environmental issues and those who want to provide an alternative toy that emphasis on early age development.
Performance Requirement	Product should be easy to pick up by toddlers. Product should be engaging the young toddler's senses, such as colours, sounds, and shapes. Product should encourage simple construction, such as stacking. Product should be easy to clean and maintain for parents.
Life-cycle	The product is intended to have at least 5 years of usage life under diligent care. It is anticipated that the inside of the translucent covers may be worn and slightly hinder the play experience over time.
End of life	The product should be easily reusable, can be passed down or sold easily. In the case of the product being damaged, it can be disposed of by standard domestic recycling collections
Materials	Predominantly wood, with translucent plastic covers, and beads. Batteries LED lights
Legal and Ethical Issues	Comply with TSD directives, and need to ensure beads and rattles are sealed safely and will pass choking test (EN71: part 1). New electronics parts must comply with Directive 2006/66/EC batteries, EN62115:2005 Electric Toys Safety and WEEE directives for end of life management.

10.4 Case study B – Global Play Inc.

Global Play Plc. is an international toy corporation with several toy brands of different target age and play types. Global Play's headquarter is in America with a number of offices around the globe; research and development and design are carried out in the offices of the intended market, manufacturing is carried out in factories in southern China and Thailand. A liaisons office is also set up in Hong Kong for managing manufacturing and exports. Global Play is a brand leader in several product categories, one of which being the singing and dancing soft toy from a licenced character image. This singing and dancing doll has a high market share worldwide.

The information used in this case study has been combined from publicly available annual reports and press releases on companies with similar profiles to our subject, Global Play Plc. Where information was unavailable from either of these companies, surrogate data based on general market trends was used. The relevant data obtained from published literature is presented in Table 10-3. Extracts from key data sources used to compile this table are included in Appendix 5.

As with most of the publicly listed companies, Global Play's prime commitment is to its shareholders through dividends (profit) and growth (share price). This focus on the shareholder value will be at the core of its corporate strategy. Lazonick and O'Sullivan (2000), highlighted the economic benefits of maximising shareholder value as a principle of corporate governance. Whilst this may be the guiding principle and ultimate metric of the corporate strategy, it can be achieved in several ways and various timescales. A good corporate strategy should give overall direction, provide goals and be understandable across all operating levels within an organisation. It was stated in previous chapter that the framework and the tool aimed to be applicable at different level of business complexity; from a product level where there are a handful of products to an overall business and corporate level where there are multiple brands with huge product portfolios. This case study aims to demonstrate how streamlined assessment within the tool can help with setting strategic directions and goals at a corporate level.

Table 10-3 Global Play company facts with 'real world' comparisons. Sources: (Hasbro 2013) (Mattel 2015)

Company Information	Global Play Inc.	Hasbro Inc.	Mattel Inc.
Established	1960	1923	1945
Markets	Global	Global	Global
HQ	California, US	California, US	Rhode Island, U.S.
Corporate mission	Play, Grow, Prosper	Play, Create, Thrive	Play to grow, play together, play with passion, play fair
Marketing Approach	Original Brand and Licence	Original Brand and Licence	Original Brand and Licence
Number of Employees (HQ)	70,000	5000	11,000
CSR report	biennially	biennially	biennially
Environmental effort	Reduce materials	Reduce materials	Reduce materials
	Reduce packaging	Reduce packaging	Reuse materials, energy and water use
	Reduce emission	Replace toxic and environmentally unfriendly materials	Reduce emission
	Improve Transport	Improve Transport	Recycling
Social Effort	Equal opportunity	Improve Working practices	Equal opportunity
	Maintain health and safety standards	Improve ethical and responsible conduct	Toy donation
	Volunteering Schemes	Maintain health and safety standards	Volunteering Schemes
	Improve ethical and responsible conduct	Encourage volunteering	Uphold health and safety standards

10.4.1 Company Mission Statement

Corporate Slogan: Play, Grow, Prosper

Citizenship Mission Statement: to help develop a fair and sustainable world for future generations, responsibly impacting our company, our products, and our planet by innovative play.

Global Corporate Strategy

Global Play strives to lead in leading the industry in its sustainable innovations. It aims to be an inspirational leader as well as market leader, therefore, in addition to excellence in financial, market and business performance. Global Play understands that a truly sustainable company

must also excel environmentally and socially. Global Play is aware that to truly achieve its citizenship mission, it begins with their own company, products and brands to passively impact societies.

Global Play has a matrix structure of global brands and regional operational divisions Innovation is centrally controlled with two global development centres in the USA and UK that works closely together. The Hong Kong liaison office acts as the in-between for managing factories and contractors from China. The company aims to optimise its environmental and social performance in both their business activities and products. To achieve this ultimate goal, three key citizenship strategic areas have been developed.

The three key citizenship strategic areas are:

Corporate

- To uphold its ethical value in all business activities.
- Putting staff wellbeing and health and safety in the forefront on all operations.
- Running staff initiated outreach programs in local communities.

Products

- To ensure the highest level of product safety.
- To maximise the products' inherited societal benefits for the users.

Planets

- To minimise their environmental impacts throughout their life cycles.
- Continue their commitment to curb energy and water consumption.
- To reduce greenhouse gas and carbon dioxide emission.

10.4.1.1 Strategic Objectives

As part of the citizenship strategy, various assessments were carried out for one specific brand to demonstrate the applicability of the tool at a high level of business complexity. Other supporting data are generated from publicly available reports of other global toy companies, detail data are enclosed in Appendix 5. Some key information is presented in Table 10-4 below:

Table 10-4 Key citizenship performance of Global Play

Citizenship Scheme Performances	2011	2012	2013	2014	2015
Environment					
Greenhouse Gas Emissions (metric tons CO_2e)					
Direct	7,656	5,985	7,347	7,222	5,237
Indirect	19,684	17,422	16,904	15,084	9,466
Total	27,340	23,407	24,251	22,306	14,703
CO2 Emissions (metric tons CO_2)					
Direct	7,533	5,886	7,229	7,178	5,229
Indirect	19,474	17,223	16,708	14,989	9,412
Total	27,007	23,109	23,937	22,167	14,641
Energy Consumption (GJ)					
Total Electricity	166,406	173,953	150,170	132,322	93,206
Fuel	77,059	74,910	76,518	77,263	65,552
Total	243,465	248,863	226,688	209,585	158,759
Water Consumption (U.S. million gallons)					
Total	16.3	13.7	13.6	13.7	9.6
Waste Recycling (U.S. short tons)	7,143	6,606	7,043	5,074	1,128
Recycling rate (%)	83%	82%	81%	73%	39%
Employees					
Incidence Rates (per 200,000 hours worked)					
Recorded Injuries and Illness	1.46	1.16	1.08	0.58	0.84
Lost Time Injuries and Illness	0.58	0.52	0.38	0.16	0.26
Lost Work Days	11.61	11.31	8.65	2.23	1.95
Work-related Fatalities	0	0	0	0	0
Community					
Employee Volunteer Hours	18,531	20,451	26,348	42,627	52,230
Philanthropic Support (million)					
Financial Support	7.3	5.4	4.7	7.7	4.4
Product Donations (est. retail value)	8.5	9.1	9.8	9.2	9.7
Total	15.8	14.5	14.5	13.9	14.1
Children Impacted (million)	4.1	3.4	3.5	3.2	3.4

Every year, Global Play has donated over 10 million toys to different social impact initiatives, however, it is important to establish that these toys are impactful in terms of their societal benefits. As well as donation, it is essential to understand the societal benefits of the toys designed and manufactured by the company. Therefore, the following objectives were devised for the Flying Wheel brand:

- To assess the overall sustainable performances of the flying wheels brand against other brands
- To identify opportunities for design improvements.
- To improve products for competing with major rivals.

10.4.2 Product Level Tool

Its leading socially and environmentally aware toy car playset brand ‘flying wheels’ has won admirations and awards from various yearly toy shows and fairs. This is one of the few brands that are promoted across the entire globe. This brand consists of parts that can be interchanged and added onto each other. Therefore, it can easily be viewed and assessed together as one entity for assessment. The brand is assessed with a streamlined tool along with other global play’s brands that are part of the company’s portfolio of preschool toys.

10.4.2.1 Strategic Positioning

Four brands were selected from the portfolio along with the ‘Flying Wheels’ toy car playset brand; Magic Blocks, Friendly Bears, and Cooking House were assessed for their environmental impacts and societal benefits as well. Magic Blocks is a building blocks brand that consists of colourful blocks that can be stacked. Friendly Bears is a soft toy brand that focuses in sprouting relationships between children and the soft toy characters. Cooking House is a brand that provides make-believe playsets and cutlery for children to act out real life scenarios in a fun and safe atmosphere. A Streamlined version of the SBA and ERPA were performed for those four brands. the results are combined and plotted onto the cost benefit matrix, Figure 10-5.

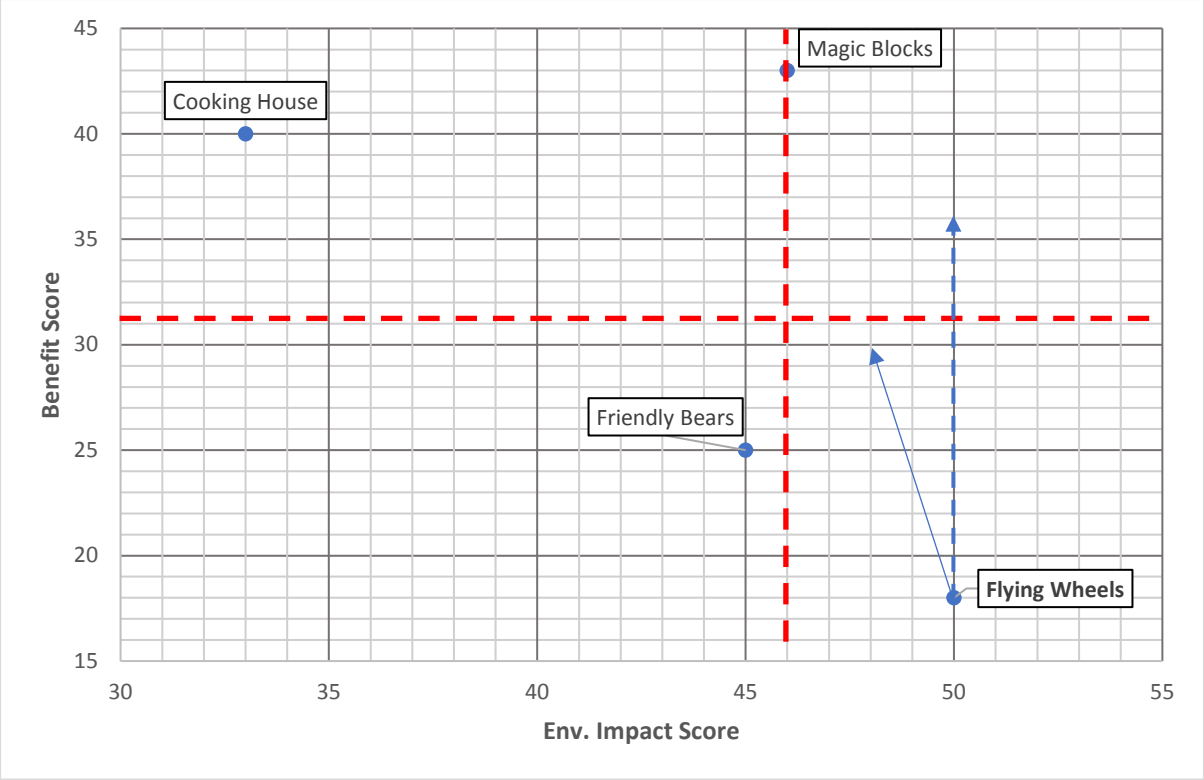

Figure 10-5 CBM plotting performances of four brands

10.4.2.1.1 CBM

The results of both SBA and ERPA are combined and plotted onto the cost benefit matrix, figure 10-5. The performance benchmarks are set at 46 for the environmental impacts and 32 for the societal benefits. Magic Blocks is sitting in the good quadrants where it is on target for both environmentally and socially. The Cooking House brand has good societal benefits but has poor environmental impacts. Both Flying Wheels and Friendly Bears are performing to the environmental targets, but under performing in terms of societal benefits.

10.4.2.1.2 Trends and targets

The trend and target for the Flying Wheel brand is set and plotted onto figure 10-5, the performance trends indicate that current existing development in design will improve in both environmentally and socially, however, it was decided that the improvement of societal benefits is more urgent. Therefore, the target was set where there will be more improvement in societal benefits and no action would be taken to improve the environmental impacts.

10.4.2.2 Targets assessment

The target is assessed in perspective of their market growth and market share as well. The Flying Wheels has high market share as it is an established brand for 20 years, it has a steady market growth, and there are peaks in market growth with each new design. This would make

the Flying Wheels brand a cash cow in the Boston Matrix. Tactical options were highlighted from putting the results of Boston matrix and the cost benefit matrix together. From which it was concluded that It would be sensible to improve its societal benefits performance.

10.4.2.3 Design brief

Design briefs should be set for brand managers within the companies. For the Global Play's Flying Wheels, societal beneficial features need to be enhanced. The brand marketing and the toy design should enhance visual and sound features for sensory stimulations. As this exercise is set for supporting strategic decision for managing the brand, there will be no further action for developing specifications as that would be carried out at the product level. The main aim of this exercise is to set out overall direction for the brand.

10.5 Comparison of Case Studies

The tool was designed in such a way that it would be applicable at a product level where products are assessed individually and at a higher brand level where groups of products within one brand are considered and assessed as one entity. This is particularly important for the toy industry as it consists of several big global corporations and many SMEs with product portfolios of various sizes. The following section will discuss: Firstly, the difference in structure and size of the two companies that were in the case studies. Secondly, the results from the case studies in terms of how understanding the products aid the incorporation of societal benefits consideration.

10.5.1 Company Structure and Strategy

The two Companies that were formulated with stimulated data are different in size and consequently their strategies and practises. Fullplay Ltd is a SME and has a simple company structure. Strategic decisions are formulated and translated into action quickly. The manufacturing and logistics are managed easily. Conversely, Global Play Plc is a global company that has several offices around the world and multiple brands that target a wide range of children in terms of age. This is significant in terms of the use of the tool, as this determines their corporate social strategies, the range of products to be assessed, and the competing products.

SMEs do not tend to have concrete CSR strategies and reports, instead it is normally embedded within the annual report, and there are little or no considerations in actual social

projects, but rather the social responsibility is being described as the responsibility to board members and shareholders. On the other hand, global company tend to have specific CSR teams that manage specific aspects of the company, regarding the three areas of concern of CSR: economic, social, and environmental. This means that there are specific schemes and projects to ensure safe working place and practises, community engagement projects and environmental targets and optimisation schemes

In terms of the products that are being assessed for future strategies. Fullplay, as an SME, has a narrower product portfolio. This makes it easier to manage design development and manufacturing logistics. . It would be easier to manage and assess a product. It would be more difficult for Global Play to keep taps on each product from a vast range of brands and products.

Apart from knowing what to assess, it is also different in terms of what to assess against. Fullplay's use of the CBM is mostly against other external competitors, while Global Play's competitors are as much internal as external. As there are multiple global brands that would be competing for resources internally, these brands and products would need to be assessed to for the determination of strategic priorities from within the corporation.

10.6 Assessment Results

The results for Fullplay's sensory blocks and Global Play's Flying Wheels brand both suggest improvements in societal benefits, however the reason behind the suggestions are different. Sensory Blocks is actually in the desirable quadrants on the CBM, however it was decided that the product should improve in societal benefits as it is assessed as a question mark in the Boston matrix and in order for the product to grow in market share, the benefits should be highlighted and enhanced. On the other hand, Flying wheels as a brand is an established brand in the market as a cash cow, but the brand is not performing to targets for societal benefits. The reason for improvement in societal benefits is obvious in this case. These two case studies show that the tool is applicable in supporting strategic decisions making by assessing and understanding the products performance in environmental impacts, societal benefits, and market performance.

10.6.1 Meeting the Original Research Aim

The tool is developed according to the framework to integrate societal benefits consideration into the toy design process. Case studies were carried out to validate the applicability of the

tool in different business situations. The case studies showed that the tool can be used in different business complexity and can support strategic decision making and drive towards a holistic sustainable approach in product design.

10.7 Summary

This chapter demonstrated the applicability of the research concepts and the tool that was developed through two case studies. It provided overviews of the two case studies and explained the purpose of the case studies. Two case studies were carried out; the first case study was based on a Hong Kong based SME, and the second was based on a multinational toy manufacturer. The results show the wider range of factors that may influence the decisions in improving the societal benefits in toy design.

Chapter 11 Concluding Discussions

11.1 Introduction

The discussions presented in this chapter relate to the major issues investigated in this thesis and summarise the research contributions. The concluding discussions are structured in accordance with the original headings identified as the research scope in Chapter 2, and highlight the key findings and contributions to knowledge resulting from this research.

11.2 Concluding Discussion

The following subsections draw together and discuss the results of the main research activities, and use the research scope to structure the evaluation of research.

11.2.1 A Review of Current Status of Sustainable Development in the Toy Industry

To provide the context for this research an extensive review of literature relevant to this research area was carried out. The first part of the review was focused on sustainable development, its background, and the implication for toy industry. One particular issue of sustainable development is the growth in resource consumption and how companies are addressing this through resource management strategies. Review in resource consumption and conservation has further cemented the research assertion in that out current practice is not sufficient, and we may/will require alternative resource allocation methods. Explorative research method was applied while carrying out this review.

In terms of sustainable development, the review has identified that economic factors are the key drivers for translation of sustainable strategies in government policies, business strategies, and public awareness, as indicated by drop in both policies and public awareness after the 2008 financial crisis. One may even argue that the so called triple bottom-line approach is skewed towards economic measures as the key driver. It was also identified that economic factors are the most effective language for communicating sustainable strategies, and this in turn inform decision in this research in the assessment

and toolkit development stages. Resource conservation management legislation and policies were also reviewed, the lack of social considerations was noticed. When social matters were mentioned, it was an extension of environmental impacts, meaning the social implication of different environmental impacts.

An overview of the toy industry was carried out, in areas such as manufacturing practices, materials used, and how the consumption of resources in the toy industry is increasing both in volume and complexity. Data for toy industry was difficult to obtain, as the industry is highly competitive and does not report everything. Only a handful of publications were found to investigate sustainability and the toy industry. These publications, in particularly the eco-toy project from the Catalan area in 2014, helped identified a few key findings: toys are not being effectively recycled, recycling data are often hard to track, most toys are made of plastics, and increasingly toys are incorporating electronics, making it vital to recycle key materials from these toys. The design of toy often does not consider the social benefits from playing with it. In terms of industrial practices, most reviews on the toy industry are gathered from past press events which focuses on safety issues, and CSR reports which focuses mainly on the positive activities surrounding environmental performance and volunteering activities as social measures, instead of social impacts of the products. These reviews have further confirmed that achieving the research aim required a novel method in assessing positive social impacts of toys.

11.2.2 A Review of Methods and Design Tools for Evaluating Sustainable Impacts of Toys

A number of tools have been developed to provide support and guidance on sustainable development. These tools were reviewed and summarise into six main categories. Most tools are descriptive rather than prescriptive, and require a degree of interpretation and adaptation when applied to a specific business. However, despite these shortcomings, advances have been made and several tools have been developed to support business at various stages during a products life-cycle. Many SPD tools are found to be ineffectual, being used later in the design process and often only considering a small range of sustainability issues. The research methods applied in this review were explorative and descriptive. The research methods have allowed a thorough understanding of the mechanisms of an extensive list of SD tools. In total, 108 SD tools were reviewed, most

of the tools have a foundation in the life cycle approach, while LCA framework is applied to a number of tools.

The two most widely used tools in the toy industry for SPD were identified, a more detailed review was performed to understand the method and application of the tool methods. These methods are namely, LCA and CSR. While the two are very different in context; LCA assesses environmental impacts of the products, while CSR assesses and plans sustainable strategies of a corporation. The main issue of LCA in relation to SPD, is that it requires huge amounts of data, which does not exist at the conceptual stage for a new product. However, it has been widely used to evaluate the environmental performance of existing products to identify areas for their improvement; the new knowledge gained can then be transferred to future design projects. A standard method for conducting environmental LCA was formalised in the ISO14040 and ISO14044 standards. This provides a framework and guidance for undertaking an LCA, which can be used to assess a single product or compare products based on their shared functionality. This shared functionality or 'Functional Unit' is fundamental to the LCA framework as it allows the variability in performance to be accommodated. This strength is also a weakness as it does not allow products with different functions to be compared or the subtleties of those functions to be considered. It is also mainly, if not exclusively, concerned with measuring the 'negative' environmental impacts of a product, in other words identifying which product is the least worse, rather than which one is the best. As such LCA is an incremental improvement tool concerned with one aspect of sustainability. It cannot answer the difficult question identified previously – 'should we be making this product at all?'. This question would require an understanding of the benefits that product achieves, mainly during its use compared to the environmental, social and economic impacts over its life cycle. Existing tools discussed so far provide pieces of the puzzle but not the whole solution.

The other tool widely used by the toy industry is CSR; this considers sustainability, and in particular 'Social' performance, at a company level rather than a product level. CSR reports usually contain activities undertaken by the company to 'offset' the impacts of the business, such as charity work or planting trees, rather than address them directly by improving the sustainability of their products. Whilst product confidentiality may be one factor for this current situation, it is likely that the ambiguity

and subjections of measuring and reporting sustainability performance at a product level can actually backfire and leave the company open to claims of greenwashing and not doing enough. It is notable how quickly an alternative view appears on social media when a company presents its own version of its products sustainable credentials. The detailed reviews on LCA and CSR has identified the shortcomings of both tools in achieving the research aim in terms of considering positive societal benefits. The third and last area of review further investigate the novel method of SLCA in addressing the positive societal benefits and the benefits of toys that are supposed to be captured by social product assessment.

11.2.3 A Review of the Social Impacts Assessment of Toys

This section of review investigated the notion of social consideration in sustainable design, and current available assessment method that considers social factors in SLCA. The research of different elements of play and the play value of toys were also reviewed for better identification of social value of toys and a potential assessment content for social values of toys. This section of review was separated into two parts; the first part was in social sustainable design and SLCA, the second part investigated benefits from playing with toys and how they aid child development.

The need for an objective and quantitatively based tool for measuring the social impacts of a product has been widely debated in academic circles and has led to a new area of research in SLCA. Impacts will occur throughout the products life cycle but are likely to be particularly prevalent during their use or ‘misuse’ phase. SLCA follows the same path as ELCA in terms of the four framework phases and the use of product function as the basis on which to quantify impacts and allow comparisons of different products. SCLA differs from ELCA in that the negative impacts can be more subjective and harder to quantify. Generation of greenhouse gasses can be quantified, and all of the emissions are accepted as being bad for the environment. Child labour is seen as a bad social impact; however, might this not depend on the degree and type of child labour and on the prevailing circumstances. If the alternative to a child working is starvation, begging or prostitution, would a balance between safe work and school not be a better option. Social impacts like work created by one product can result in unemployment for workers on another product. On the other hand, the definition of positive impacts considered in SLCA were explored. Three novel approaches were investigated, and shortcomings were

discussed. It was concluded that positive impacts consideration was still work-in-progress and have its difficulties. Despite these obvious difficulties, SLCA has continued to be developed by academics, and could ultimately allow social considerations to be given the same prominence and attention in SPD as environmental and economic ones.

The second part of this review was the explanatory reviews on the benefits of toy playing. There are many benefits for children associated with playing and most toys are designed to facilitate this process in one form or another. It is clear that play, despite its apparent initial simplicity, is actually a complex process involving the development of many physical, mental and social skills. Much works were reviewed on evaluating the benefits of play to children and this work would be instrumental in the development of a method to assess the societal benefits associated with the intended play functions of a toy that is disused later in this chapter. Play is a relatively abstract process but is widely accepted as being best measured from a process perspective rather than a goal-based perspective – the 'means' rather than the 'end'. While 7 categorisation models were summarised and compared, it was found that the Kudrowitz and Wallace (2010) model were the most comprehensive and most suitable to be used as foundation for sustainable assessment tools development. In addition to establishing a basis on which play can be evaluated this review also provided a means of classifying play types. This provided a solid academic base upon which to develop the societal benefit assessment method for toys although the exact process for doing this and incorporating this data required further research and development, this process is summarised in the following sections.

11.2.4 Literature Review Discussion

Overall the review has identified a greater need for including sustainability considerations early on in the product design process and a gap in existing tools to facilitate this process namely the assessment of positive 'social' benefits resulting from the 'intended' use of the product. It has also been established that the current trajectory of human activity is taking us way beyond the capability of the planets current natural resources to make this sustainable. Clearly a more radical approach is needed to achieve the changes needed for a sustainable future and if not forthcoming then radical changes in terms of how we cope with the consequences of our actions will be needed. One such scenario proposed in this thesis is that as these resources become increasingly depleted and demand outstrips supply, alternative approaches to accessing these resources will be needed. One solution

would be the requirement to justify the use of resources based on the societal benefits achieved from their use. In this case, companies in the future may have to justify the benefits of their products in order to access the resources to manufacture them. This assertion was supported by the reviews carried out. It made clear the need for a framework and method to allow the societal benefits of a product to be assessed to fulfil the research aim. Secondly a means of integrating these new criteria and metrics into a company's existing product portfolio and design strategy will be needed if a coherent and comprehensive approach to sustainable development is to be achieved.

11.2.5 Development of a Societal Benefit Assessment Framework

As identified from the literature review and discussed in the previous sections, there is currently no established and accepted mechanism for assessing the societal benefits of a product within the existing range of sustainable design methods and tools. This highlighted the need for a stepwise approach to undertaking such a study in accordance with the approach taken to other forms of sustainable assessment such as LCA, thus a framework consisting of a number of stages was developed by this research in accordance with the underlying principles of ELCA and SLCA. The suitability of the LCA framework as the foundational structure was discussed in Chapter 7.

In developing this framework, it also became evident that the potential range of societal benefits was hugely complex in both scale and diversity. This was particularly apparent when developing the detailed methods used within the framework to quantify and assess the impacts. To achieve this, a specific example was selected and a method was developed to allow this product to be assessed. This focus was beneficial in establishing the detail of the activities and steps required within the method, however there was a concern that in so doing it may lose its broader application as a generic framework and method. Although the data used is specific to this application the principles and steps underpinning the method are generic and could be easily adapted to a new product category. However, it would require an understanding of the benefits arising from the use of the product and how these functions relate to the user benefits that subsequently equate to the societal benefits. As with LCA , this development of inventory data and assessment methods would be a natural consequence of its acceptance and ongoing application.

Whilst the framework used LCA as a basis for its development there are a number of key differences that sets the SBA framework as unique and novel. In LCA the functional unit is the basis that allows a quantitative and comparative assessment to be made. This also limits ELCA to comparing products with similar functions. In the SBA framework, the fundamental basis upon which this is based is the need to compare products with different functions based on the societal benefit. However, society can be divided into many separate groups where it would be unethical to compare these groups and suggest one group is more important than another. Hence it was felt that the societal group should form the basis of the study, not the products functions. This makes sense when considering the same product but different societal groups. Disposable nappies could be justified for children up to 2, but reusable nappies for older children.

11.2.6 Realisation of Societal Benefit Assessment Method

As stated the SBA framework provided the step-wise approach, however a detailed method was required in order to undertake the quantification and assessment phases. The selection of toys for children aged 2-4 as the focus for developing a method was based on the availability of data concerning the benefits of play and types of play categories that provided a greater degree of confidence to the characterisation and allocation steps. In order to improve the accuracy of the assessment and allow the consideration of both quantitative and qualitative factors, analytical hierarchy process was applied in part using a pairwise comparison to weight the scores from play type by importance.

In order to increase the likelihood of the tool being taken up by industry, it was felt that it needed to be capable of being embedded within the existing corporate sustainable design process and product management strategy and integrated with existing assessment methods and tools. Therefore, a toolkit was developed consisting of existing tools and incorporating the additional functionality of the SBA assessment methodology.

The SBA methodology was developed applying action research methods. The development was iterative, and it was improved several times with the kind collaboration with Dr Amanda Gummer and other industry participants whose opinions helped to increase the accuracy and usability of the assessment method.

11.2.7 A Toolkit for Integrating SBA into Sustainable Management and Design

Whilst the framework and method provide the means to assess a product's societal benefits, this is only one consideration of many in terms of a company's sustainable manufacturing strategy and SPD. The toolkit provides a means of integrating SBA with SLCA, ELCA and economic considerations at each level of product management from the individual product to the corporate brand portfolio. In doing so it supports SPD as well as providing a strategic tool for corporate sustainability. the toolkit was developed with the intention that other SD tools may be applied into this standard structure if applicable.

Although significant research time and effort has been spent on developing the ideas and framework contained in this thesis, the author fully acknowledges that the method and toolkit is only a prototype to demonstrate the applicability of the research. Clearly its commercial use would require significant investment to enable the development of a fully tested, user friendly, software tool.

11.2.8 Demonstrate of Research Applicability Through Case Studies

For the purposes of validation and demonstration of the research concepts, two case studies were identified as being suitable to demonstrate the effectiveness of the framework, method and toolkit. A clear objective of these case studies was to follow a systematic implementation of the SBA framework proposed by this thesis, and to show its feasibility and applicability in selecting the most sustainable route for the company to improve its sustainability and societal benefit profile. The two case studies primarily considered the same product category of toys. The major difference was in the type of company and its strategic aims and objectives. The purpose of this was to demonstrate how the toolkit could be applied to different sizes and complexities of organisations

11.2.9 The Vision for the Future of Societal Benefit Assessment

The need for greater efforts in sustainability is becoming increasingly apparent as the world adapts to the consequences of our activities. A significant body of research supported by real world evidence is beginning to shift world opinion and convince many of the sceptics who would like to continue with business as usual. The current approach has been to develop tools and strategies that support the existing economic models of increased production and consumption. Whilst a number of technological innovations and

incremental improvements have extended the timeframe it is inevitable that more radical approaches will have to be considered in the future.

Societal benefit assessment is at the early stages of acceptance as a necessary consideration in sustainable development. However, it does not seem reasonable that the privileged few can continue to manufacture and consume products which have such little purpose or value whilst the majority of people struggle to meet their most basic needs. In a world view where social justice and equity take precedence over individual greed and selfishness, societal benefit assessment could form the basis upon which companies compete for access to future resources both physical and financial. As with LCA, it is hoped that the adoption and extension of SBA by the research community will eventually lead to its eventual industrial acceptance.

11.3 Limitations of the Research

The research reported in this thesis has investigated an area which is highly complex and diverse in its scope. Research into assessing a company's or product's social impacts has somewhat divided the academic community between SLCA and CSR. The scope of this research has extended this to societal benefits and identified how this can be incorporated at a product level SLCA and at the corporate level CSR through the SBA Toolkit.

However, an inherent facet of any research is its limitations due to the time and resources available. Thus, a number of the limitations of this research are outlined below.

i. Lack of access to quality data due to the confidentiality surrounding the toy design and production process.
ii. Investigation into the social impacts associated with toy use and play was not fully validated due to this being a novel approach, and further examination would be preferable.
iii. Lack of inclusion of detailed studies exploring the impacts of toys on society through child development enhanced by play
iv. Comprehensive and varied case studies assessing the ease of use of the toolkit within a broader range of existing sustainability and product portfolio management systems was not carried out.
v. Detailed consideration of future legislation and its potential impact on current resource consumption and material supply was not considered sufficiently.

Chapter 12 Conclusions and Further Work

12.1 Introduction

This chapter identifies the major conclusions drawn from the author's research and proposes possible avenues for further extension of this work.

12.2 Research contributions

The author has identified the following as the important contributions made by this research in the area of life cycle assessment and sustainable product design:

i. Highlighting the significant shortcomings in life cycle assessment, which can only be used to compare products with the same functions, not products with different functions.

ii. Extending the scope of existing knowledge on sustainable product assessment by identifying the future manufacturing and supply chain requirements resulting from the continued decline in available resources and growing global demand for new products.

iii. Definition of a novel approach for assessing the societal benefits of a product during the use phase of its life cycle.

iv. Development of a comprehensive societal benefit assessment framework and associated assessment methods to provide a means of ensuring resources can be directed towards the manufacture of products with the greatest societal benefits.

v. Development of a sustainable design Toolkit to support the implementation and integration of the SBA framework within a company's existing strategic product portfolio management process.

vi. The wide range of factors that must be considered and quantified during the application of the framework, method and toolkit have been demonstrated through the case studies presented in this thesis.

12.3 Conclusions from the Research

The conclusions drawn from this research are as follows:

i. Resource depletion has been widely recognised as a major issue for manufacturers and for the future health of the world economy. Despite much research and investment in sustainable design and manufacturing strategies, these current initiatives fail to achieve the improvements needed to slow this decline. It is therefore inevitable that on our current trajectory, manufactures will need to compete more intensely for resources in the future. One industry that has been identified as being particularly susceptible to this future scenario is the toy industry where the benefits to society of its products, whilst present, are often ambiguous.

ii. A number of tools have been developed and made available to industry to support their initiatives to become more sustainable manufactures. These tools focus primarily on assessing the environmental and to a lesser degree the social impacts of their products or company. What they fail to address is the fundamental value to society of the products that they make, which are predominantly designed and manufactured according to potential sales and profit margins.

iii. The review of current LCA methods and tools clearly highlights a current capability gap in their ability to provide this form of societal benefit assessment. This is due partly to the current lack of need from industry that is tied to the current economic model of consumer demand and to the fundamental basis upon which LCA is founded that restricts it to comparing the environmental impacts of products that share the same functionality.

iv. SLCA was developed to expand the scope of LCA to social impacts, whilst still an emerging area of research, it remains focused mainly on the negative impacts of the product in terms of its manufacture and disposal, and uses the functional unit as the basis of any comparative study. The functions of the product during the use phase and the benefits derived thereof are omitted because the products being compared share the same functions (functional unit) and therefore can be assumed to have the same benefits.

v. In general, the potential benefits of some toys to children have been well studied in terms of play value and classification, although this is largely based on qualitative

research and observations. However, no link is made to the resources required to achieve the benefit or to the subsequent benefits to wider society resulting from the child's personal benefit.

vi. The framework developed and presented in this thesis provides a step-wise approach to assessing the societal benefits of a product, and allowing the comparison of products with different functions to be made based on the benefits to a pre-defined societal group.

vii. The method developed for supporting the implementation of the framework provides a systematic approach for each of its phases. The development of this method based on a specific application of comparing two toys provided a more detailed and focused range of benefit categories and functional inventory data. Whilst the data used is specific to this scenario, the method developed can be applied universally requiring only the substitution of relevant data.

viii. The toolkit developed as part of this research supports the implementation and integration of the SBA framework and methods within the company's overall sustainable product design systems, thus allowing Societal benefit to be included within the company's product portfolio management strategy.

ix. The case studies presented in this thesis clearly demonstrate that the implementation of the framework, method and toolkit by a toy manufacture, supports the decision making within the company to move towards a more balanced portfolio of products which combine resource efficiency and societal benefits that could be used to evidence the company's future claim on restricted resources.

x. Current economic models which rely on price to determine access to resources are both unsustainable and ineffective in a future where essential material resources are either squandered or priced beyond the reach of the majority of the population. To ensure security of supply for future generations and to provide some degree of social equity and cohesion, an alternative approach is needed based on the products intended benefits to society.

xi. Although the results of this research has advanced the understanding and application of societal benefit assessment within LCA and SPD, clearly a number of additional areas which require further investigation as highlighted in the final section of this chapter.

12.4 Further Work

The author recognises the following areas of work as the most valuable extensions of the current research.

12.4.1 Development of more accurate data on user benefits

Whilst the intended functions of a product are relatively straightforward to identify, the quantification of the potential user benefits derived from these functions is more difficult to determine. Furthermore, the relationship between user benefit and the ultimate societal benefit is subjective and can vary according to a societies own values and requirements. More research is therefore needed from academics with specialist knowledge in the areas of social needs to provide the data used by these studies.

12.4.2 Additional case studies and validation

Further studies should be conducted, initially with the toy industry to further develop and validate the application and results of the framework, methods and toolkit. Parts of studies should be compared to the results obtained from other forms of assessment to evaluate the accuracy of results obtained. Additionally, the same study undertaken by a different assessor would identify the reproducibility of the method.

12.4.3 Extend the application to other product categories

The selection of toys as the basis for the research development and case studies was based on both the authors own interests, availability of data and the clear potential for its application. For this SBA framework to achieve the wider adoption enjoyed by LCA, it will be necessary to develop the functional inventory databases and benefit categories across a broad range of industry and products types.

12.4.4 Development of a computer assisted SBA support tool

In order to make SBA framework and methods available for commercial use, the development of a computer aided tool capable of supporting an SBA study at a process and data input/calculation level.

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Appendices

Appendix 1 – Conference Paper LCE 2015

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The 22nd CIRP conference on Life Cycle Engineering

Expanding the Scope of LCA to Include 'Societal Value': A Framework and Methodology for Assessing Positive Product Impacts

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Abstract

As resources become scarcer, efficiency improvements alone will not bridge the widening gap between supply and demand, resulting in the need for additional non-financial mechanisms to ensure the fairer allocation of resources. This paper asserts that, in the future, companies will need to demonstrate their products' positive contribution to society as well as minimising their negative environmental/social impacts. A review and analysis of existing tools and assessment methodologies identifies current capabilities and highlights the need for 'Societal Value' assessment that considers both quantitative and qualitative factors .This paper concludes by proposing a systematic framework for addressing the 'Societal Value' of products as part of an integrate sustainability assessment and allows the evaluation and comparison beyond products' shared functionality.

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Keywords: Sustainable development; Product Development; Eco-design methodology

1. Introduction

In the past fifty years, the global environmental impacts resulting from human activities have become increasingly apparent and the need to take immediate action to address these has been broadly accepted by the majority of the world leaders. Regular media coverage on issues such as climate change, loss in biodiversity and pollution are being increasingly reported (1). However, whilst the current environmental damage resulting from our activities and actions is clearly apparent, the longer term consequences, social and economic as well as environmental, are not always so obvious. For example, the slow recovery in the US and Europe from the recent financial crisis can be attributed in part to the restriction in global supply and increasing prices of key raw materials, food and energy costs. This in turn has led to a widening gap between rich and poor, an increase in poverty, and a decrease in social mobility (2). Whilst politicians have been largely ineffectual in dealing with the global challenge of disconnecting economic growth from environmental degradation, many of the more enlightened manufacturers have begun to address the sustainability of their own operations, which in turn has a direct impact on society. On our current consumption trajectory it is predicted that these problems will further intensify.

There have been a number of forecasts and assessments carried out by governments and corporate organisations that attempt to understand these 'near term' global changes (3–6). From a review of these recent reports, two key trends have been identified with regard to the availability and distribution of resources, which can be summarised as follows:

- Resources will continue to be depleted, with energy and water scarcity causing increasing cost and supply problem.

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- Growth in global populations combined with emerging markets and improved living standards in developing countries will increase global resource consumption.

It can be concluded therefore that the gap between global resources supply and demand is likely to widen further. It has been estimated that 1.5 planets worth of resources are required to support the world's current population, in terms of resource consumed and waste generated. It is predicted that this will increase to two planets by 2050 (7). If global populations continue to grow and consume at present rates, the reliance on finite resources to meet their needs and wants will eventually deplete all accessible resources (8). Resource efficiency has been traditionally driven by economic objectives (9); maximising financial profits through efficiencies in labour, materials and energy consumption (10), the same approaches have been transferred to embrace sustainable strategies where greater emphasis have been placed on not just the profit and loss but conservation of resources and efficient consumption of materials, water and energy (11). However, it has become increasingly evident that these efforts are not enough (12); radical changes are required in order to meet the targets. Furthermore, Stern (2007) asserted that in order to mitigate the effects of our current impacts, a reduction of 80% is required (13). It is therefore clear that to meet such challenging targets, a strategic, integrated, and radical approach will be required (14). One such approach could be the allocation of resources based on the value of a product to society, rather than the current financial mechanisms.

To some degree the Toy industry is ahead of others industries in this regard, (e.g. automotive, white goods, food) as some toys are marketed on their 'play value' rather than desirability alone (15). These 'play values' can include factors such as educational, communication, fitness and motor skills (16–18). The value of toys is evident when toys are being used as "tools" to explore the world and develop social, cognitive and motor skills. As with other sectors, the toy industry has grown dramatically since the industrial revolution and the growth in net wealth and disposable incomes. Nowadays, toys are mostly mass manufactured and come in many different forms, these variations create a number of categories of toys and encourage different innovative ways of play (19,20). However, the toy market is very crowded and increase competition and pressure to maintain and increase sales has led to over consumption and a throw away culture. Furthermore little consideration has been given to the end-of-life management of toys, where discarded products most likely end up in landfills or incinerators.

Current efforts in improving sustainability in the toy industry have been focused in material reduction and substitutions, reduction in packaging and improving working conditions within manufacturing facilities. These are all valuable activities and should be encouraged, however they may not be the solution to stop or reduce global resources depletion. It was reported that an average child in the UK receives 44 new toys a year (21) and owns 238 toys while only plays with 12 of them most of the time, that is 5% of the total. (22) These facts indicated that toy supply is actually exceeding demand and resources are being needlessly and inefficiently consumed.

2. Sustainable Concepts and Tools

The three dimensions of sustainability have received differing degrees of attention from research communities over the years (23). Sustainable development debate was dominated by environmental issues in the 1980s to mid-90s. Subsequently, economic concerns were connected and included into the debate in the mid-90s to late 90s and social issues only took up more focus by the late 90s (24). This is due to a shift of stakeholders concern (25).

It is widely agreed that the three dimensions have been prioritised unevenly (26). This was mainly because sustainable development was generated from a combination of the green movement of the 1960s and the "basic need" advocates of the 1970s, but also assessing social elements presents difficult measuring challenges (27). Indeed, social considerations have almost been treated as some kind of afterthought in sustainability. OECD (2012) points out that social sustainability is considered in terms of the social implication of environmental politics instead of an equally integral component of sustainability (6). Currently, there are a number of commercially available tools, methods and concepts aimed at supporting companies achieve sustainability improvements to specific aspects of their product, process or operations. These tools can be used stand-alone or together, however, only a handful actually considers the social factors and these are underdeveloped and do not provide a fully comprehensive assessment (25,28).

A key assertion of this paper is the need to evaluate the positive impacts of a product during its life cycle. Economic assessment is already well advanced in this regard. Tools such as life cycle costing (LCC) (29), and the Lean practices have enabled the economic assessment from an enterprise level to a product level (10). Conversely, sustainability assessments that evaluate the other two dimensions (social and environmental) offer little considerations on the positive impacts (sustainable gain) and recommendation for improvement tend to focus on reducing the negative impacts (sustainable loss). This may drive towards a net improvement, however enhancing the social and environmental gain will be more effective. Assessment for the inherent social value or gain will have increasing importance as financial capability will not be the only deciding factor for fair resource distribution in a material scarce world.

2.1. Assessment of Sustainability Tools

A list of sustainable concepts and tools were compiled from a number of sources including previous assessments (30). These tools were then assessed according to their application to the 3 pillars of sustainable development. The assessment also intended to highlight the need for social tools that appraise the positive benefits regarding the social pillar.

108 concepts and tools were listed from a compilation from three previous studies (30–32). The tools were grouped into seven main categories; analytical, checklists and guidelines, concepts, footprints, organising, rating/rankings, and software/expert systems, and summarised in table 1. From this total of 108 concepts and tools, 38 covered all three

Table 1Available sustainable tools and their categories

	ECO	SOC	ENVIR	Int	Semi-Int
Analytical	20	12	17	9	9
Checklists/ Guidelines	12	9	8	6	4
Concepts	13	9	14	8	6
Footprint	17	15	7	5	2
Organising	11	7	9	5	6
Rating and Ranking	9	5	6	5	1
Software/ Expert Systems	10	2	8	0	9
Total	92	59	69	38	37
Positive	23	11	14		
Negative	35	24	48		

sustainability pillars, whilst 37 considered just two. The remainder considered only one aspect.

Where possible the tools were also evaluated on their inclusion of positive and negative impacts, the results of which are also recorded in table 1. From the original 108, 61 economic tools, 46 social tools and 72 environmental tools were identified to measure the positive and negative impacts. Overall, there are more tools that measure the negative sustainable impacts than the positive impacts. It is clear that there is a lack of social tools in particular the ones that measure the positive impacts.

For example, the two most widely used social sustainable tools, namely Corporate Social Responsibility (CSR) and Social Life Cycle Assessment (SLCA), both demonstrate the potential for measuring the positive impacts. However, both tools seem to offer little or no assessment in regards to the actual functional societal benefits of a product during a product uses phase, something that is mentioned in the SLCA guidelines (33). In practice, CSR is more effective as a tool to set strategic goals for an organization and it will be difficult to determine the societal benefits of a product from CSR reports. On the other hand, SLCA is a product specific assessment that evaluates the entire life cycle, however most of the social impacts measured are within the production and distribution supply chain, and the consumer subcategories are enterprise system related, such as health and safety, consumer privacy and feedback mechanism.

3. Strategic Framework

The following section proposes a framework for supporting toy companies in achieving these aims at strategic, tactical and operational stages within the organisation.

In order for a company to develop the objectives and actions required to implement a holistic sustainability strategy, their current position, trajectory and velocity must first be established. In smaller companies it may be possible to achieve this by simply focusing on the individual products and/or services, however in larger organisations, the range and diversity of products often requires a degree of 'business segmentation' by grouping product, services or functions into common categories (e.g. divisions, departments, categories, markets, brands). Meanwhile in multi-national conglomerates, further segmentation may be required into its autonomous business groups or geographic regions. It is envisaged that an organization would enter the framework at it relevant level of complexity as shown in Figure 1, the organization would then follow the sequential stages running horizontally.

At the higher levels of complexity, it is the groupings that are considered and not individual products. This means that the information used will be more qualitative and general rather than quantitative and specific. However, mechanisms exist to improve the accuracy of this information, such as AHP and Fuzzy Logic, which would be integrated into the tool to support these stages. By starting at the higher levels, the business is able to quickly identify those parts of the business that need to be prioritized. These groups will then be addressed at the next level of lower complexity and the process is repeated until the lowest complexity level is reached, the product level. It should also be mentioned that the outputs from the lower levels can then be used to inform the higher levels in an iterative process that ensures continuous improvement, and increasing accuracy. The stages of the framework at the product level are now discussed in more detail but the same principles apply to the previous higher levels.

This first stage of the framework will support the assessment of the business at each level, from division to product, sector to service and translate this understanding into a series of definitive actions and objectives.

3.1. Framework at Product Level

The framework for the stages in the lowest complexity level (product level) is presented in the form of an IDEF0 diagram, see Figure 2. The processes directly link to the three stages of control, where a product plan is outlined in the strategic stage, a design brief is formed at the tactical stage and a design is produced in the operational stage. The advantages of using IDEF0 diagrams is that it clearly highlights the requirements and corresponding mechanisms for each process box as well as the input and output. Requirements are represented by arrows going into the boxes from the top (e.g. Legal Requirements at the Design Toy stage). Mechanisms are represented by arrows going into the boxes from the bottom (e.g. the corresponding officers in charge of finishing the task of that stage). It is also worth noticing a product design specification (PDS) is set within this stage and will be used in production and quality control as a benchmark. The framework is also set up for design feedback coming out from the operational stage as a feedback input loop for the strategic stage. The entire framework aims to produce a design that will have maximized the product's societal value. Sustainable tools can be applied at different stages of the framework. Organisational tools such as CSR can be used for the strategy formulation as the input for the first stage. Conceptual and rating tools can be used at the tactical stage for design brief setting and analytical tools and checklists can be used during operational stage in design to ensure the product is meeting the strategic targets. The results from these analyses can subsequently be fed back for continuous improvement at the strategic stage.

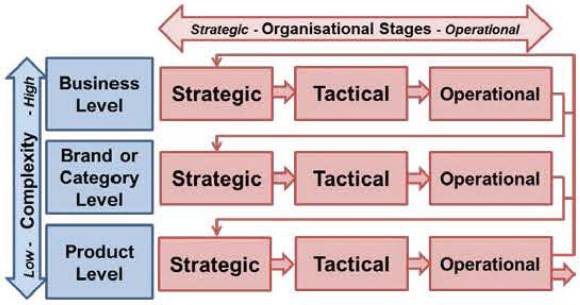

Fig. 1 Level of complexity and organisational stages

3.2. Strategic Stage at Product Level

A sub-model is formed for the strategic stage, see Figure 3, it consists of four processes which describe the sequential procedures in order to outline a product plan for the tactical stage downstream. The four stages follow an established strategic management procedures; analysis, goal-setting, strategy formulation, strategy implementation and evaluation and control. These procedures are represented as Identify Current Product Performance, Set Performance Target, Identify Adjustment, and Plan Adjustment respectively. Evaluation and control comes in the form of performance feedbacks which is formulated downstream from a number of stakeholders including middle managers, product designers, engineers and customers. There are two "blind" mechanisms carrying out the process of Identify Current Product Performances as the participation of Designers and Managers are not always necessary. It may also be noted that the performance target is set according to future sustainable drivers as well as internal reporting. A comprehensive product plan will be produced when all four processes are accomplished.

3.3. Cost-Benefit Matrix

A two axes / four grid matrixes assessment tool proposed would consider the societal benefits against the environmental costs as illustrated in Figure 4. The boundary of this tool is set around the toy industry. The scope for measuring environmental impacts is based on existing environmental LCA with particular attention paid to abiotic resource consumption to justify the use of resources. The scope for societal assessment is based primarily on the use phase of the toy where educational, communication, fitness and motor skills are the key factors. The product with the least environmental cost and most social benefit is sitting in the most desirable position. The 4-grid assessment is set up similar to the Boston matrix, and it is intended for the tools to be complementing the Boston matrix for strategic recommendations. The Boston Matrix or growth-share matrix was first developed by the Boston Consulting Group (BCG) (34) to help companies decide on their internal investment and marketing strategies (which products and parts of the business should get the investment). This tool will be the main instrument for the strategic stage as it can visually represent the current performance and identify the targeting position and path to identify the targets.

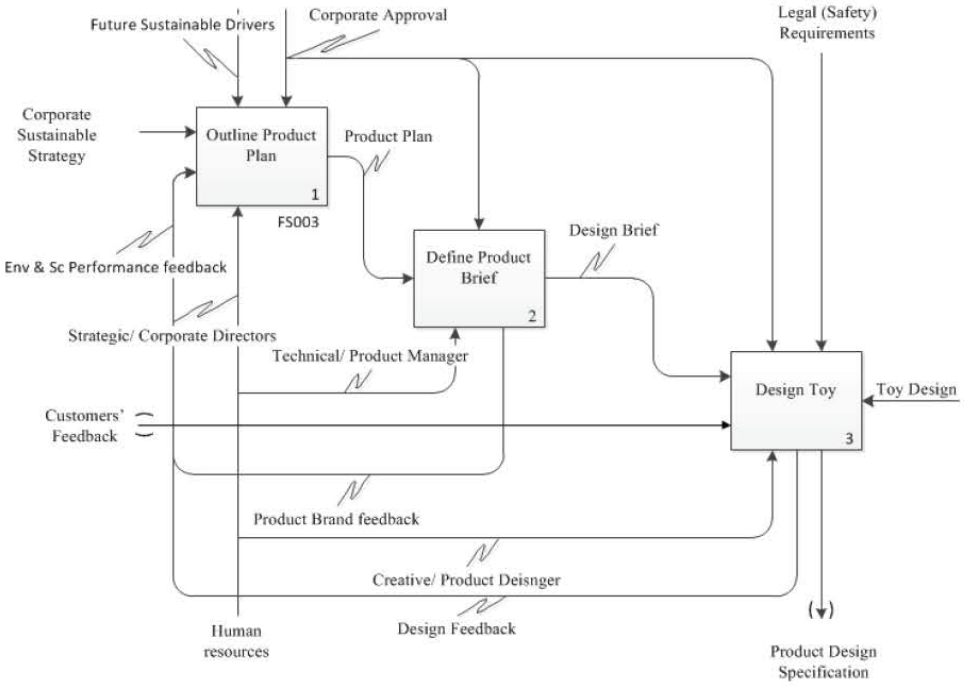

Fig. 2 Product level framework

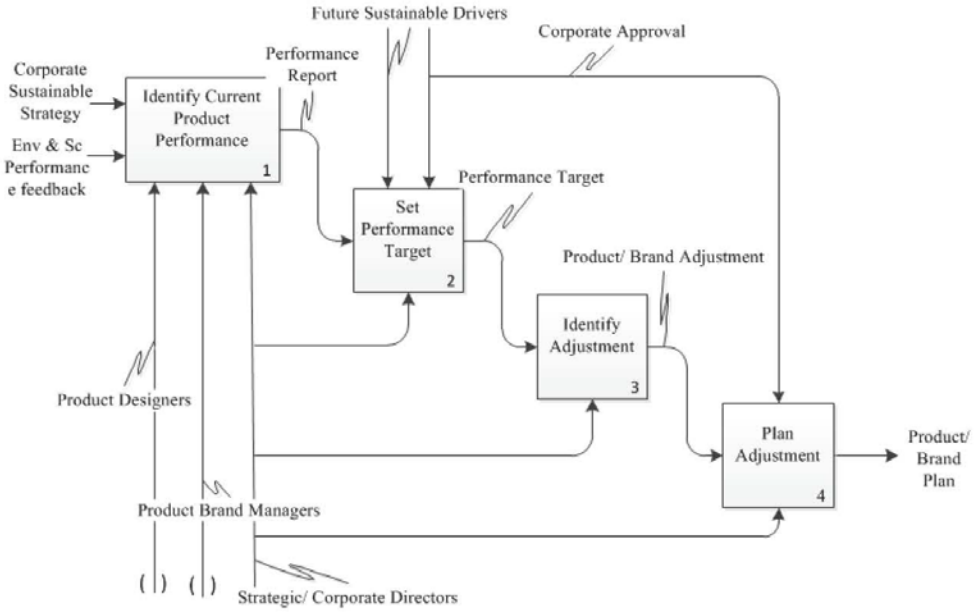

Fig. 3 Strategic stage framework: Outline product plan

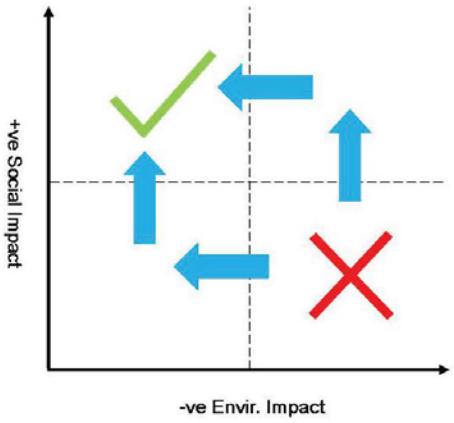

Fig. 4 Cost benefit matrix

4. Conclusion

Current sustainability tools are inadequate for supporting the radical changes required to meet the future manufacturing and societal needs. As non-financial mechanisms become increasingly important for the allocation of resources, so the ability to demonstrate a product's wider range of benefits, environmental and social, will become increasingly necessary. The toy industry has been identified as being particularly vulnerable to the impacts arising from resource depletion, but with significant societal benefits currently unaccounted for. The framework proposed in this paper provides a systematic approach to the holistic evaluation of a company's product(s) at a strategic, tactical and operational whilst providing an iterative approach to the levels of business complexity. To implement this framework, a number of existing tools can be used, however a new tool is required to enable the evaluation of societal benefits during the products' use phase. To enable the evaluation within the toy industry, four factors have been identified; educational, communication, fitness and motor skills.

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Appendix 2 – Conference Paper ICMR 2016

This paper was presented at the 14th International Conference on Manufacturing Research. ICMR 2016, Loughborough, UK and published in the proceedings the same year

Societal Benefit Assessment: An Integrated Tool to Support Sustainable Toy Design and Manufacture

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Abstract. A framework and methodology for assessing the societal benefits of a product was developed based on the assertion that, in order to access future diminishing resources, manufacturers will need to demonstrate both the social and environmental benefits of their products. This paper follows on from this published research and presents an integrated tool to support the implementation of this framework and methodology within the toy industry during the design and development phase. A simulated case study is used to exemplify the application of this tool and to support the concluding discussions.

Keywords. SLCA; Sustainable Design, Product Development; Toy Manufacturing; Societal Benefit Introduction

1. Introduction

Previous research published by the authors presented a rational and framework for a step-wise approach to evaluating the societal benefits associated with a company's products, which in turn could be evaluated against the environmental performance to allow a company to develop a sustainability strategy for its product portfolio [1]. This was based on an assertion that as materials become scarcer, companies will have to compete for these resources based on environmental performance and the value of the company's outputs to society (societal benefits) [2]. This framework provides a systematic approach to undertaking this 'Societal Value Assessment' at various levels within the organisation; Strategic, Tactical and Operational, whilst supporting the design process to enable these additional considerations to be included. Further research identified the need for both a tool to support the implementation of the framework within companies and a specific assessment methodology tailored to the company's industry sector. For this study the Toy industry was selected to demonstrate the application of this research. This paper provides an overview of the decision support tool and provides a detailed description of the assessment methodology for the Toy Industry. The paper begins with a brief introduction to the framework, followed by an outline plan of the tool and a detailed description of the assessment methodology using simulated data to demonstrate its application within an industrial context.

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2. Overview of Framework and Tool

The framework as shown in figure 1 provides an overview of a systematic approach to incorporating societal benefits into manufactured products. The sustainable toy design framework consists of three stages: assessment & target setting (strategic positioning), trajectory correcting & prioritisation (tactical plans) and design. The aim of the strategic framework is to facilitate the translation and communication of the strategic goals into design and manufacturing of toys.

2.1. Design Support Tool

A cost benefit matrix (CBM), as proposed in previous paper, is a strategic tool that was developed for the first stage of the framework [1]. It supports all three steps of the strategic positioning. The CBM plots the environmental impacts against societal benefits. It can be divided into four grids by setting baseline performances for both environmental impacts and societal benefits. This would effectively set up a matrix. This matrix can be used for sustainability performance positioning, forecasting and performance targeting. The environmental impacts are assessed through the use of the life cycle assessment (LCA); whereas the assessment for societal benefits required development of a novel methodology. There is a need to develop a specific societal benefit assessment as existing methods do not have a consensus definition of positive societal benefits and there are no established methods to assess the user values from the function of the products, hence the societal benefits of the product. The following section describes the mechanisms of such assessment methodology. The methodology was developed for the toy industry because toys, as products, are not considered to meet an essential human need, such as food, warmth or shelter [3]. Toys therefore exemplify the need for societal benefits assessment in order to demonstrate the hidden developmental benefits that result from the actions of the children playing with the toy.

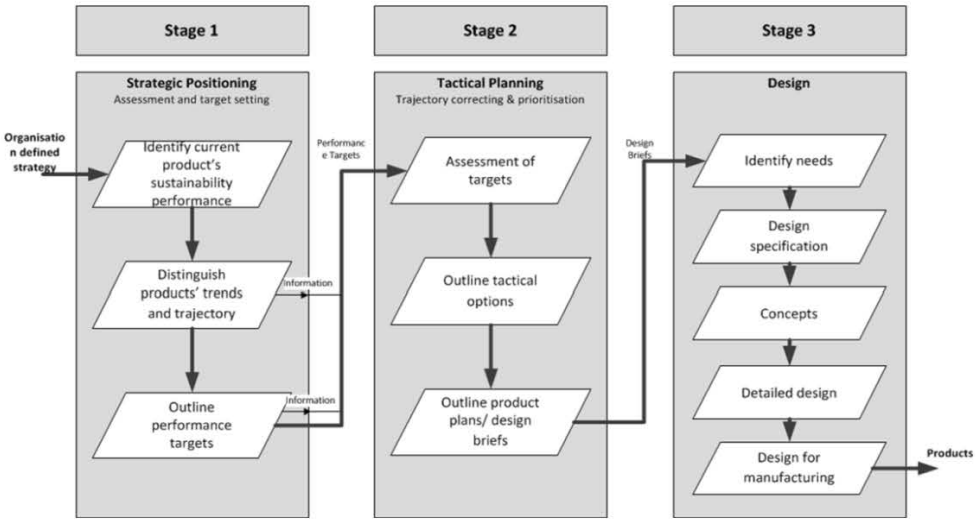

Figure 1. Framework Diagram.

3. Societal benefits assessment methodology

For the purpose of the assessment method, it is necessary to define the terms "play values" and "play benefits". Firstly "play" is defined as the quality of mind during enjoyable, captivating, intrinsically motivated and process focused activities. Hence "play value" is the affordance of play. This definition of play value means that it focuses mainly on the action or activity of play and the affordance of an enjoyable, captivating, and intrinsically motivated play from the toys. On the other hand "play benefits" focus on the effects that are created after play. Therefore play benefits are the skills and growth that are developed through playing. Thence play value is not the play benefits, they are closely related. The higher the play value that a toy brings the more effective it is benefiting child's development.

The structure of the Societal Benefits Assessment (SBA) methodology, as illustrated in figure 2, is based on the similar approach to that used by the ISO14040 standard for LCA [4]. In place of inventory impacts, the SBA substitutes play types, and for mid points the SBA equivalent is play benefits. The individual steps undertaken during an assessment are similar to that of an LCA with the initial scoping and definition of the societal group, aggregation and allocation of the play types , and classification and characterization into play benefits, with an optional final stage of weighting and grouping into a single score.

For the purposes of demonstrating the SBA methodology two toys with a similar function and societal group (children 12 to 24 months) have been chosen for assessment and comparison. It should be noted that the age range within the societal group chosen represents a key stage of child sensory-motor and preoperational development, according to the Piaget's stages of development [5].

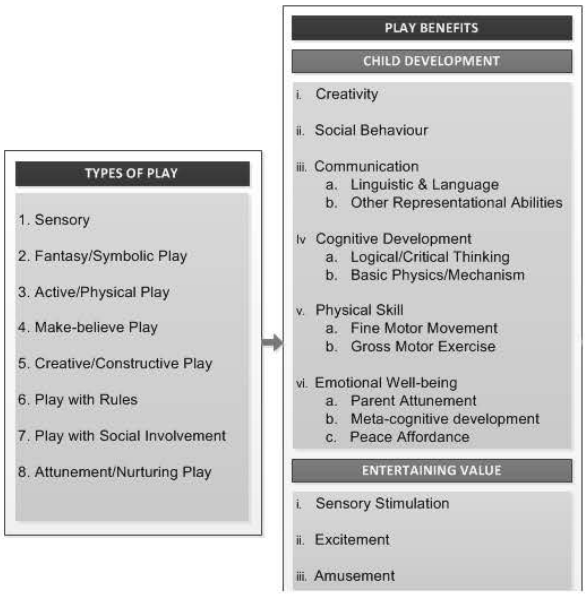

Figure 2. SBA Diagram

3.1. Inventory stage

In traditional LCA, inventories are selected before being quantify as there is an extensive list of environmental inventories. Conversely, SBA for toys have a limited amount of play types, which is the equivalent of inventories in this case. The data collection phase consists of the scoring of all the play types of the toys. The play types are adopted from previous work on the play pyramid, in which a list of play types were summarised from previous researches [6]. The play types defined and used in this case study are: sensory play, construction play, challenge, fantasy, social play, solitary play, free play, play with rules, mental play and physical play.

Sensory play refers to how the toys and play feels, looks, smells, tastes and sounds. Fantasy play is referred to the ability of the toy to puts player into a world or state of mind that is outside of the ordinary. Construction play refers to toys and play that allows users to create. Challenge play refers to play that tests one's abilities against others or oneself.

The rest of the play types can be referred to play characteristics, they refers to the atmosphere or the setup for which the toys are play in. for example social play and solitary play refers to whether the toys enable children to play together or alone. One toy can be played both socially and solitarily, and may bring different benefits from different play. This is the same case for free play vs play with rules, and mental vs physical play. All of the play types are scored from 0 to 10, where 0 means the toy being assessed does not afford that type of play and 10 means it fully affords that type of play. The scores are modified objectively to relate to the societal scope, this process is similar to relating inventory data to the functional unit in LCA.

A list of importance weighting will be calculated with the use of analytical hierarchy process (AHP) [7]. AHP generates the weightings objectively through pairwise comparisons of each play types. The score on the play types will be multiplied by the importance weighting for further classification and characterisation into play benefits. The table below shows the scores and adjustment of two soft toys where product A is a standard teddy bear and product B is one with electronic songs system.

Table 1 Play type score and priority weight

	Product A	Adj. Product A	Product B	Adj. Product B	Priority Weight
Sensory	6	6.00	8	8.00	100%
Construction	1	0.10	2	0.21	10%
Challenge	1	0.10	1	0.10	10%
Fantasy	5	1.53	7	2.14	31%
Social Play	3	0.22	5	0.36	7%
Solitary Play	8	1.87	8	1.87	23%
Free Play	10	3.74	7	2.62	37%
Play with Rules	1	0.10	2	0.21	10%
Mental	2	0.95	4	1.90	48%
Physical	7	6.25	7	6.25	89%

3.2. Assessment stage

Figure 3 below shows how the play types are classified into play benefits. The play types are given scores of 0 to 5 where 0 means that particular play type do not contribute to that benefits and 5 means it strongly contributes to that play benefits. The list of play benefits are summarised from a number of literatures that focuses on the relationship between playing and child development [8]. Play benefits can be grouped into two categories: child development and entertainment value. Child development entails physical development, cognitive development, emotional well-being, etc. entertainment value entails sensory stimulation, excitement and amusement.

	Child Development											Entertainment Value		
	Creativity	Social Behaviour	Communication		Cognitive Development		Physical Skill		Emotional Well-being			Sensory Stimulation	Excitement	Amusement
			Linguistic & Language	Other Representational Abilities	Logical/Critical Thinking	Basic Physics/Mechanism	Fine Motor Movement	Gross Motor Exercise	Parent Attunement	Meta-cognitive development	Peace Affordance			
Sensory	0	0	0	1	3	5	3	3	1	0	4	5	4	3
Construction	5	1	0	1	3	5	4	2	2	1	4	0	2	3
Challenge	3	2	4	3	5	1	0	0	1	4	1	0	3	2
Fantasy	5	2	2	3	3	0	0	0	2	4	5	0	3	3
Social Play	3	5	5	3	2	0	0	0	1	3	1	0	3	4
Solitary Play	3	1	0	0	3	0	0	0	0	3	5	0	1	1
Free Play	5	0	0	0	1	0	0	0	0	5	2	0	4	4
Play with Rules	1	3	0	2	2	0	0	0	0	1	0	0	2	1
Mental	4	0	0	0	5	3	0	0	1	5	2	0	0	0
Physical	0	0	0	1	0	1	5	5	0	0	0	4	0	0

Figure 3. Play benefits classification

Societal benefits scores are calculated by multiplying the inventory scores to the classification scores. The scores of each play benefits are divided by the theoretical maximum scores to calculate the potential fulfilled of each play benefits. The results of both product A and B are very close, but product B is generally better in most categories. Product A has an overall societal benefit of 53% and Product B 63%. It is also worth noticing that product B has much better results in sensory stimulation and both fine and gross motor development. This may be caused by the integration of electronic music units in the soft toy. However, previous LCA carried out on musical teddy bear concluded that the environmental impact of the battery operated toy is far higher than without [9]. Therefore, it is expected that product A's societal benefits can be improved by integration of non-battery operated rattle or music box type mechanism. That would increase product A's societal benefits without compromising its environmental advantage over product B.

4. Conclusions and further work

This paper presented a systematic framework that integrate consideration of societal benefits and aid the strategic planning and design of products. The tool that is developed for the implementation of the framework is reviewed. This paper described the structure and mechanism of the societal benefit assessment, which is fundamental to the design support tool. The methodology is demonstrated through the case study comparison of two soft toys. It was demonstrated that the result can be used for design improvement recommendations. Further work is required to improve the methodology and tool through an iterative process. Case study with actual toy is planned.

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Appendix 3 – Journal Paper: Production & Manufacturing Research, 2017

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An integrated tool to support sustainable toy design and manufacture

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ABSTRACT

Whilst the importance of considering the positive societal benefits of a product, in addition to other social, economic and environmental factors, has received wider recognition, its definition, concept, and integration into product design are not so well developed and studied. A literature review on sustainable design identified the potential of Social Life-Cycle Assessment as a tool to measure societal benefits of products; however further analysis of sustainable assessment methods highlighted the lack of a coherent definition and method for achieving this. This paper presents a framework for including societal benefits within a product portfolio management process and a prototype tool which aims to support the implementation of the framework within the toy industry, specifically on the societal benefit assessment of the products during the first stage. Finally a simulated case study of three toys is used to exemplify the intended application of this tool and to support the concluding discussions.

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SLCA; sustainable design; product development; toy manufacturing; societal benefit

1. Introduction

With growing material scarcity, future scenarios suggest that as competition for access to these resources increases, alternative economic models will be required if a fair and equitable society is to be maintained (Rahimifard, Sheldrick, Woolley, Colwill, & Sachidananda, 2013). Specifically it is suggested that other factors such environmental performance and the value of the company's outputs to society (societal benefits) (Shin, Colwill, & Young, 2015), will have a significant influence on future manufacturing sustainability. The framework providing a systematic approach to undertaking this 'Societal Value Assessment' at various levels within the organisation; was presented in a previous paper and is summarised in Section 2 (Shin et al., 2015). Further research identified the need for a specific assessment methodology tailored to the company's industry sector, which is further summarised in Section 3 (Shin & Colwill, 2016). This paper presents the design for a decision support tool to assist in the implementation of the framework and assessment methodology within the Toy industry. This industry was selected as it provides a good example of a sector where

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the products differ in terms of their societal benefits and where they are targeted at specific age groups.

2. Methodology

This research aims to provide a systematic approach for manufacturers to incorporate societal benefit considerations into their broader sustainable product management and design practices. In order to achieve this aim the following five objectives were established; to identify existing methods for assessing a products positive societal benefits through a review of relevant literature, to establish the limitations of these current approaches and identify areas for improvement, to develop a framework for including societal benefit assessment within existing sustainable manufacturing methods, to develop a methodology for assessing the positive societal benefits of a specific product category, and to present a design of a decision support tool for the implementation of the framework and methodology.

A literature review of current 'sustainable' product assessment methodologies was conducted to identify where the positive societal benefits of a product were being included. A number of concepts and frameworks were identified, such as Corporate Social Responsibility (CSR); however Social Life Cycle Assessment (SLCA) was the most advanced in considering a product's impact throughout its life cycle. An in depth review of SLCA was conducted and three main approaches for measuring positive impacts were summarised and scrutinised.

Following this review a framework was developed to incorporate positive societal benefit considerations into sustainable product management and design (Shin et al., 2015). The assessment phase of the framework identified the need for developing product category specific assessment method for measuring societal benefits. The framework and methodology are based on the widely-accepted ISO14040 LCA standards, but include some significant additions and modifications.

From this a tool was developed to support the implementation of the framework within a specific product category. The tool brought together a compilation of assessments and methodologies to follow the steps set out by the framework. A case study was carried out in order to test and validate the tool. Both the assessment methodology and the tool were developed to be used by the toy industry. Toys were selected for the case study as the benefits of toys are ambiguous, and yet most researchers in early development would point out the importance of play. Three toy products were chosen for this case study to demonstrate the application of both the societal benefit assessment methodology and the decision support tool.

3. Literature review

3.1. Sustainability

The concept of sustainability began to emerge as environmental issues were first brought to the public's consciousness by the release of 'Silent Spring' (Carson, 1962). Heightened public awareness led to a wave of greenwashing by companies who tried to capitalise on these consumer concerns with dubious claims rather than substantive improvements. Increased public pressure also put pressure on governments to respond which further highlighted the lack of understanding as new policies and legislation failed to deliver the required benefits (Chitnis,

Sorrell, Druckman, Firth, & Jackson, 2014). This knowledge gap was soon embraced by the academic community as a growing number of researches aimed to better understand the ecological factors and effects. In 1987, the UN Environment Commission Report set the tone for sustainability efforts to follow. More commonly known as the Bruntland report, it defined sustainable development as *'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'* (World Commission on Environment & Development, 1987). The fundamental principle of sustainability is development that considers economic, environment, and social issues, which is often referred as the three pillars of sustainability (Elkington, 1997; Hansmann, Mieg, & Frischknecht, 2012; Kajikawa, 2008; Schoolman, Guest, Bush, & Bell, 2012). These principles have been adopted into product design practices to various degrees over the past decades and design for sustainability theories and practices are thus developed.

3.2. Sustainable product design tools

Sustainable product design has three distinctive phase over the years; Green design, Eco-design, and Sustainable design (Argument, Lettice, & Bhamra, 1998; Bhamra & Lofthouse, 2007; Keitsch, 2012). Green design takes into account the impact of the product on the environment whilst Eco-design aims to minimise environmental impacts while meeting cost, quality, and performances goals. As a result eco-design has been more broadly accepted and adopted by industry as it recognises the commercial environment that companies must operate in. Sustainable design aims to take this one step further by balancing the environmental and economic concerns of eco-design with social considerations (the triple bottom line). As these phases evolved so a range of product design tools were developed to support the implementation of these new considerations within the design process, with social considerations being a recent addition. Currently these design tools can be grouped into six categories; frameworks, analytical tools, checklists and guidelines, rating and ranking tools, software and expert systems, and organising tools. A recent review of 108 product design tools that considered at least one of the three 'pillars' identified that only 59 considered social issues, compared to 92 with economic and 69 with environmental considerations(Shin et al., 2015). Based on these numbers alone one might assume that social considerations in product design are close to reaching parity with environmental ones, however further investigation shows that this is not the case. A report by the OECD (2012) states that social sustainability is largely considered in terms of the social implication of environmental policies instead of an equally integral component of sustainability. These findings were substantiated by the review which found that of the 59 design tools that included social considerations only 18 did so with equal emphasis to environmental. In fact the majority of tools reviewed tended to be specific to one 'pillar' for example Life Cycle Assessment (LCA) only considers the environmental impacts whilst economic considerations are well advanced with tools such as life cycle costing, sustainable supply chain practices, and lean production practices (Chiarini, 2014b, 2014a; Finkbeiner, Inaba, Tan, Christiansen, & Klüppel, 2006; ISO, 2006a, 2006b; Mostafa, Dumrak, & Soltan, 2013; Womack, Jones, & Roos, 1990). This is to be expected with financial sustainability being the main driver in commercial enterprises.

Although the need for social considerations in sustainable assessment is slowly growing, it is widely acknowledged that the three pillars of sustainability have received differing degrees of attention in sustainable product design tools (Colantonio, 2007; Drakakis-Smith,

1995; Hussain, Ahmad, & Case, 2015; Marghescu, 2005). One of the reasons for this is that economic and environmental aspects can be quantified more accurately and with a higher degree of objectivity. Social aspects on the other hand can be highly subjective and difficult to quantify often having directly opposing benefits or impacts (Neugebauer et al., 2014). Furthermore, many of the social impacts associated with a product occur during its use phase which can be highly variable and complex making it difficult to assess accurately. However, the majority of the benefits to the user and society are generated during the products use; these benefits can be regarded as the positive social impacts. Current sustainable design tools offers little consideration for positive impacts and only a handful of tools that identify and quantify the positive impacts of products (Shin et al., 2015).

3.3. Positive impacts in sustainable assessment

A key assertion of this paper is the need to assess the positive impacts of products throughout their life cycles. However, there is little consensus on the definition of positive impacts and on methods that incorporate them into impact assessments (Shin et al., 2015). To a certain extent, the development in SLCA embodies the evaluation of positive impacts. The assessment boundary of SLCA is set in relation to an Area of Protection, which is inferred to be human well-being. According to the SLCA guideline, human well-being is described as the state of an individual's life situation (Benoît & Mazijn, 2009). SLCA can be carried out on two different levels: generic product chain on a general level and/or actual product chain of specific product. Generic assessments are often carried out to identify social hotspots. The results are used to highlight potential risks of significant negative social impacts and risks to brand reputation instead of the positive benefits that the products brings about (Benoit-Norris, Cavan, & Norris, 2012).

In comparison to its environmental life cycle assessment (ELCA) predecessor, which largely considers only negative impacts, SLCA also includes positive impacts relating to social factors (Ekener, Hansson, & Gustavsson, 2016). However, these positive impacts are sometimes simply the absence of a negative one. For example, a factory's strategy of not using child labour is considered to be a positive impact, whereas in reality, the elimination or reduction of child labour is really only achieving a neutral or reduced negative impact. While the concept of positive impacts has arisen in recent years, there is still no shared definition of positive social impacts (Sala, Vasta, Mancini, Dewulf, & Rosenbaum, 2015).

SLCA guideline defines positive impact as impacts that go beyond compliance specified by laws, international agreements and certification standards. This indicates that social benefits/ social security issues are only considered positive only under the assumption that they provide additional benefits to the stakeholders. To be precise, this means benefits above the level expected and already given in society. Therefore, positive impacts should cause a 'net gain' in human well-being. Furthermore, similar to ELCA, which SLCA inherited, majority of the researches in SLCA so far mainly focuses on negative impacts or generic hotspot assessment on potential negative impacts. Thence, there are no consensus, well-developed, clear definition of positive impacts and methods that truly incorporate these into impact assessment.

Various ways of addressing positive impacts are identified from reviews of literature. Ekener-Petersen and Finnveden (2013) inverted the issue by measuring the lack of/ low level of positive aspects as negative impacts. However, this approach has limitation in identifying

positive impacts. Benoît and Mazijn (2009) expanded this approach by setting performance target points that the impacts are assessed against, thus positive and negative impacts can be determined from the performance target points. Ramirez, Petti, Brones, and Ugaya (2014) also adopted this approach, however positive and negative impacts were not distinguished.

A second approach is use by Ciroth and Franze (2011), where negative and positive impacts are rated by assigning values from 1 to 6, (1 for positive and 6 for very negative impacts). This approach is easy to use; however there are arguable elements such as assessing the lack of forced labour as a positive aspect, whilst this merely put it back to neutral impacts at best. Another approach to address positive impacts is the theory of hand printing, proposed by Norris (2013). Hand printing attempts to measure the positive impacts in terms of avoided negative environment impacts that would have contributed to the environment footprint. While the activities discussed in hand printing involves interactions between individuals and social groups, the fundamental theory is still environmentally linked.

Ekener et al. (2016) divides the subcategories in the SLCA guidelines into positive and negative impacts, and suggested tentative indicators for the 12 positive social impacts that were identified. However, there is no proposed way to identify, measure, and assess the beneficial user values. While life cycle approach should assess the entire life cycle of products, it can be argued that societal benefits (user values) are the most important social impacts as they characterise the products and fulfil the needs of products. To put it simply, all the other positive or negative impacts should not be made if the products are not fulfilling a need, thus should not be manufactured in first place. Therefore, it is important to assess the benefits of products in particularly during their use phase. The next section outlines a framework of societal benefits assessment.

4. Framework for incorporating societal benefits into sustainable product design

The framework as shown in Figure 1 provides an overview of a systematic approach to incorporating societal benefits into manufactured products. The sustainable toy design framework consists of three stages: assessment & target setting (strategic positioning), trajectory correcting & prioritisation (tactical plans) and design. The aim of the strategic framework is to facilitate the translation and communication of the strategic goals into design and manufacturing of toys. The main focus of this research falls primarily within the first and second stages of this framework, specifically the development of a novel social benefit assessment methodology (SBA), incorporating the SBA results with the product's environmental performance and integrating this within the company's product portfolio management review process. It is intended that this framework can be implemented within the company's existing management and design processes. Thus stage three is primarily concerned with how the outputs from the earlier stages can be incorporated into the company's existing design process.

4.1. Societal benefits assessment

Firstly, this assessment is developed to measure the societal benefits of products. It is called 'societal' as it intends to measure the benefits of products for the greater society instead of individual social issues. For the assessment method, it is necessary to define the terms

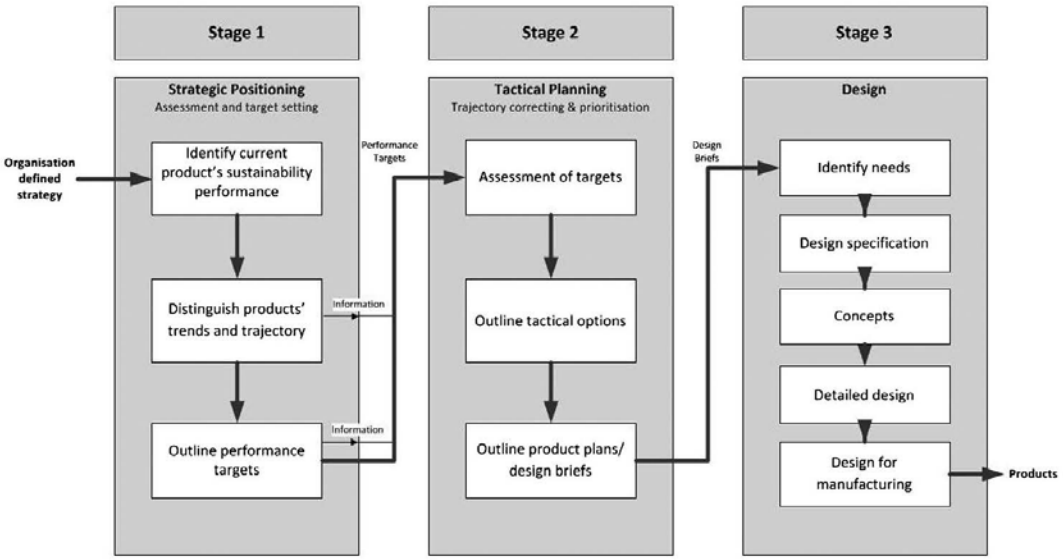

Figure 1. Framework for incorporating societal benefits into sustainable product design.

'play values' and 'play benefits'. 'Play' is defined as the quality of mind during enjoyable, captivating, intrinsically motivated and process focused activities. Hence 'play value' is the affordance of play and the higher its value the more effective the toy is in benefiting child's development. This definition of play value means that it focuses mainly on the action or activity of play and the affordance of an enjoyable, captivating, and intrinsically motivated play from the toys, whilst 'play benefits' focus on the skills and growth that are developed through playing i.e. the effects that are created after play (Kudrowitz & Wallace, 2010). Therefore play value and play benefits, whilst closely related, are not the same.

The structure of the SBA methodology, as illustrated in Figure 2, is based on the similar approach to that used within the ISO14040 standard for LCA (ISO, 2006a, 2006b). In place of inventory impacts, the SBA substitutes play types, and for mid points the SBA equivalent is play benefits. The individual steps undertaken during an assessment are similar to that of an LCA with the initial scoping and definition of the societal group, aggregation and allocation of the play types, and classification and characterization into play benefits, with an optional final stage of weighting and grouping into a single score.

For the purposes of demonstrating the SBA methodology a case study of three 2–3 years old toys have been chosen for assessment and comparison; an interactive singing and dancing soft toy, a pull-along toy with small parts inside, and some wooden sensory blocks with colourful panels were assessed. It should be noted that the age range within the societal group chosen represents a key stage of child sensory-motor and preoperational development, according to the Piaget's stages of development (Bee & Boyd, 2012).

4.1.1. Inventory stage

In traditional LCA, inventories are selected before being quantified as there is an extensive list of environmental inventories. Conversely, SBA for toys has a limited amount of play types, which is the equivalent of inventories in this case. The data collection phase consists of the scoring of all the play types of the toys. The play types are adopted from previous work on the play pyramid, in which a list of play types were summarised from previous

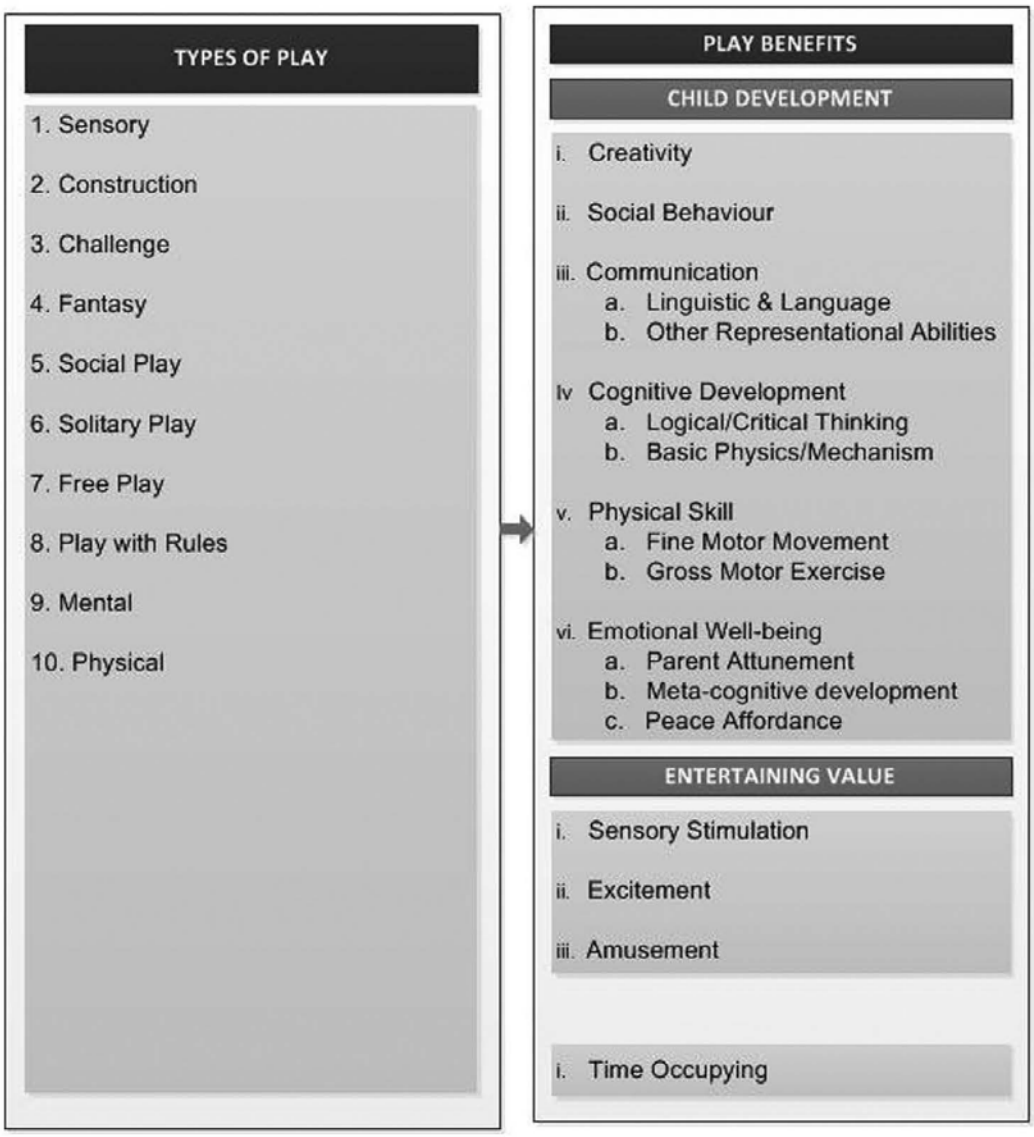

Figure 2. Societal benefit assessment methodology.

researches (Kudrowitz & Wallace, 2010). The play types defined and used in this case study are: sensory play, construction play, challenge, fantasy, social play, solitary play, free play, play with rules, mental play and physical play.

Sensory play refers to how the toys and play feels, looks, smells, tastes and sounds. Fantasy play refers to the ability of the toy to put the player into a world or state of mind that is outside of the ordinary. Construction play refers to toys and play that allows users to create. Challenge play refers to play that tests one's abilities against others or oneself.

The rest of the play types can be referred to play characteristics, they refer to the atmosphere or the setup for which the toys are played in. for example social play and solitary play refers to whether the toys enable children to play together or alone. One toy can be played both socially and solitarily, and may bring different benefits from different play. This is the same case for free play vs. play with rules, and mental vs. physical play. All the play types are scored from 0 to 10, where 0 means the toy being assessed does not afford that type of play

and 10 means it fully affords that type of play. The scores are modified objectively to relate to the societal scope, this process is similar to relating inventory data to the functional unit in LCA. The scores are weighted to their importance to that specific age. The importance weighting will be calculated with the use of analytical hierarchy process (AHP) (Saaty, 2008). AHP generates the weightings objectively through pairwise comparisons of each play types.

AHP is a one of the more recognised approaches for multi-criteria decision-making. It is normally used to establish a hierarchy of importance for alternative options selection, such as selecting manufacturing strategies for multiple customer requirements (Hofmann & Knébel, 2013). Within the process, a priority weight is determined for each option. It is this process that was adopted into the societal benefit assessment methodology.

The priority weights are calculated following the Saaty approximation method. This method involves comparing the importance of each pair of play types. The number of pairwise comparisons required follows a $n(n-1)/2$ relationship, in this case, there are ten play types, and therefore 45 comparisons are needed. A judgment matrix is generated with 10 rows and 10 columns. A normalised matrix is obtained from the judgement matrix by dividing each entry in each column by the total of that column. The average of each row is obtained by adding the values in each row of the normalised matrix and dividing the sum by the number of entries in each row. The result is the priority weight of the alternative. A consistency test is performed to ensure that the pairwise comparisons are consistent.

The score on the play types will be multiplied by the priority weighting for further classification and characterisation into play benefits. An example of the scoring chart is illustrated in Figure 3.

4.1.2. Assessment stage

Table 1 below shows how the play types are classified into play benefits. The play types are given classification score of 0–5 where 0 means that particular play type does not contribute to that benefit and 5 means it strongly contributes to that play benefit. The list of play benefits are summarised from a number of literatures that focuses on the relationship between playing and child development (Goldstein, 2012; Whitebread et al., 2012). Play benefits can be grouped into two categories: child development and entertainment value. Child development entails physical development, cognitive development, emotional well-being, etc. entertainment value entails sensory stimulation, excitement, and amusement.

A societal benefit value is calculated by multiplying the inventory score by the classification score. The societal benefit values for all benefits are averaged and converted into a societal benefit potential by dividing it by a theoretical maximum benefit value. The individual play benefits values were consistent with similar qualitative assessments carried out by toy and children development experts such as the ones that are evaluated by The Good Toy Guide (Fundamentally Children, 2017). The overall societal benefits potentials of the singing and dancing soft toy, the pull along toy, and the sensory blocks are 50, 58 and 53% respectively.

There are two concerns with the assessment methodology:

(1) The scoring classifications should be reviewed and refined, as the results can have a bigger differentiation. The overall scores do show the difference between products, however some results in the individual benefit potentials are not consistent with

Product Name Fullplay Colourful Sound Sensory Blocks	Score	Adj Scores
Sensory	9	9.00
Construction	6	3.04
Challenge	3	0.64
Fantasy	0	0.00
Social Play	2	0.10
Solitary Play	7	0.86
Free Play	10	3.15
Play with Rules	5	0.45
Mental	4	1.56
Physical	4	2.94
Product Description		
It consists of a few colourful boxes filled with coloured beads and balls. It allows children to sort them, stack them and making different sounds and noise with them. The hollow boxes allow children to look through and see a world with different colours. These blocks should engage the children and develop basic ideas like shapes, colour and sound recognition. They would encourage fine motor skill development and creativities. This toy is assessed through the tool along with other identified competitors'.		
Intended age	12 months to 2 yrs	

Figure 3. Play type scoring chart for wooden sensory blocks.

real life expert opinions. More expert inputs would be preferable in classifying play type into playing benefits.

(2) The setup of the assessment lean towards favouring toys with multiple features, which can explain the pull-along toy scores in which the toy provides good features for both gross and fine motor developments. This causes potential concern with toys being overrated by the assessment. This problem is similar to ELCA, where detailed results should be reviewed for critical judgements before making key decisions. The assessment methodology provides clear transparent steps to be retraced, and in some respect, it is more important than a definitive score in subjective decision-making.

4.2. Cost benefit matrix

Cost Benefit Matric (CBM) is the integration and presentation of the results from LCA and SBA. CBM essentially plots each product's environmental and social performances onto a

Table 1. Play benefits classification.

	Child development											Entertainment		
			Communication		Cognitive development		Physical skill		Emotional well-being					
	Creativity	Social behaviour	Linguistic & language	Other representational abilities	Logical/critical thinking	Basic physics/ mechanism	Fine motor movement	Gross motor exercise	Parent attunement	Meta-cognitive development	Peace affordance	Sensory stimulation	Excitement	Amusement
Sensory	0	0	0	1	3	5	3	3	1	0	4	5	4	3
Construction	5	1	0	1	3	5	4	2	2	1	4	0	2	3
Challenge	3	2	4	3	5	1	0	0	1	4	1	0	3	2
Fantasy	5	2	2	3	3	0	0	0	2	4	5	0	3	3
Social play	3	5	5	3	2	0	0	0	1	3	1	0	3	4
Solitary play	3	1	0	0	3	0	0	0	0	3	5	0	1	1
Free play	5	0	0	0	1	0	0	0	0	5	2	0	4	4
Play with rules	1	3	0	2	2	0	0	0	0	1	0	0	2	1
Mental	4	0	0	0	5	3	0	0	1	5	2	0	0	0
Physical	0	0	0	1	0	1	5	5	0	0	0	4	0	0

graph. As shown in Figure 4, the y axis represents the environmental impact scores from environmental assessment in the form of single points. This can be calculated by software such as SimaPro or the Eco-indicator 99 worksheet which utilises key information from Eco-indication 99 database or Streamlined assessment like Environmentally Responsible Product Assessment (ERPA) (Hochschorner, 2003; Pré Consultants, 2000; SimaPro UK, 2016). The x axis represents the societal benefits factor, which is determined from applying SBA. The products' performances are plotted onto a graph, this visualises the performances and makes it more straightforward to compare performances. A matrix can be set up by setting benchmark performances for both environmental and societal performances; illustrated as dash lines in Figure 4. These targets are set by the practitioners who are carrying out the assessment. In the case of a toy company, these will the predetermined strategic goals in the form of environmental and societal benchmark performances.

5. An integrated tool for incorporating of societal benefits in sustainable design

A tool is developed based on the same structure of the framework proposed in the previous section. The overall inputs and outputs are illustrated by an IDef0 diagram as illustrated in Figure 5. it clearly highlights the requirements and corresponding mechanisms for each process box as well as the input and output. Requirements are represented by arrows going into the boxes from the top (e.g. Legal Requirements). Mechanisms are represented by arrows going into the boxes from the bottom (e.g. the corresponding officers in charge of finishing the task of that stage and methods required for the task). Thus, the data required and information feeding out of each process are clearly defined and indicated.

Figure 1 shows the expanded system of the overall product level tool. It clearly demonstrates the three stages of the tool: Strategic positioning, Tactical planning and operational design/redesign. The strategic directions are fed in as input into this tool from the brand level management. It feeds into the strategic planning stage, a LCA and SBA are carried out

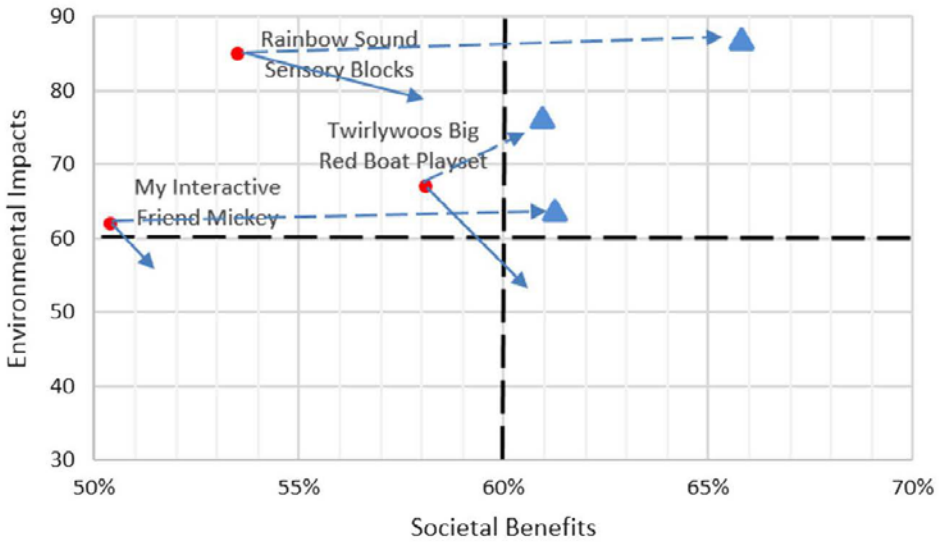

Figure 4. Cost benefit matrix.

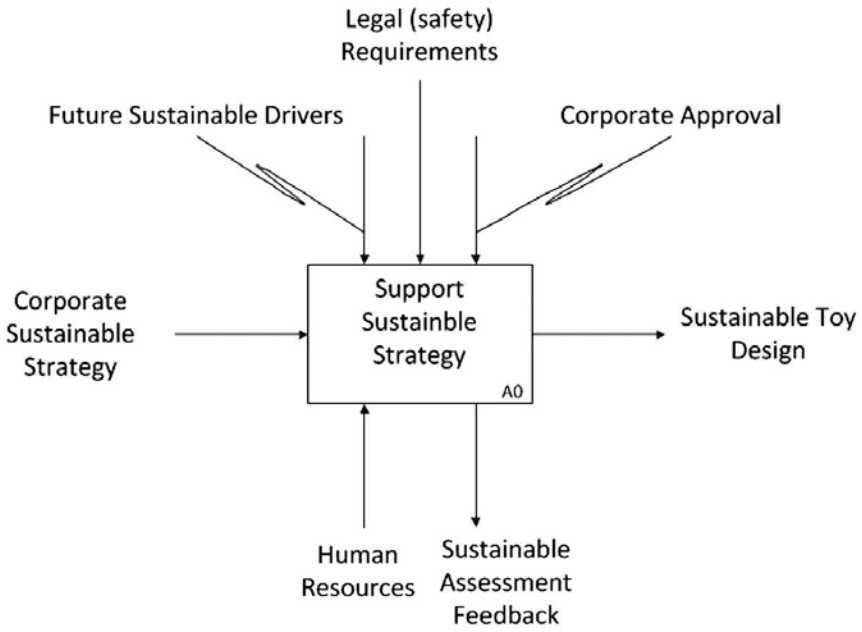

Figure 5. Overall view of the integrated tool for incorporating of societal benefits in sustainable design.

and the results are combined in CBM matrix. The presentation and the use of CBM will be discussed in more details in later section.

5.1. Stage one – strategic positioning

This tool aims to answer three strategic questions about the product(s). The results will aid the determination of the targets that will set the directions for the entire manufacturing company. The three questions are: 'How is/are the product(s) performing in terms of the social and environmental sustainability?', 'What is the products' future performance?' and 'How should the products be doing in the future?'

The three steps in the tool are set up to answer these questions and aid to develop a clear set of targets and goals for the tactical planning stage. The three steps in the strategic planning are Current Products' Performance Assessment, Products' Trends & Trajectory Analysis, and Performance Targets Formulation. Figure 6 shows the steps with the corresponding methodologies and requirement in an IDef0 format.

5.1.1. Current products' performance assessment

This step determines the sustainable performance of the product/products, both environmentally and socially. Two methodologies are adopted for this step; ERPA is used for assessing the environmental performance while SBA is applied for the social performances. Results from both the SBA and ERPA are combined into the cost benefit matrix, Figure 4. The results show that all toys have acceptable performances. However, it is important to strive to improve. Just having more than 50% for societal benefit potential is not enough. Therefore, it is important to set the targets to be higher than 60% for any improvements in design. Environmentally, the wooden sensory blocks are performing well and does not necessarily require any major changes. Whereas, the two toys that required batteries and

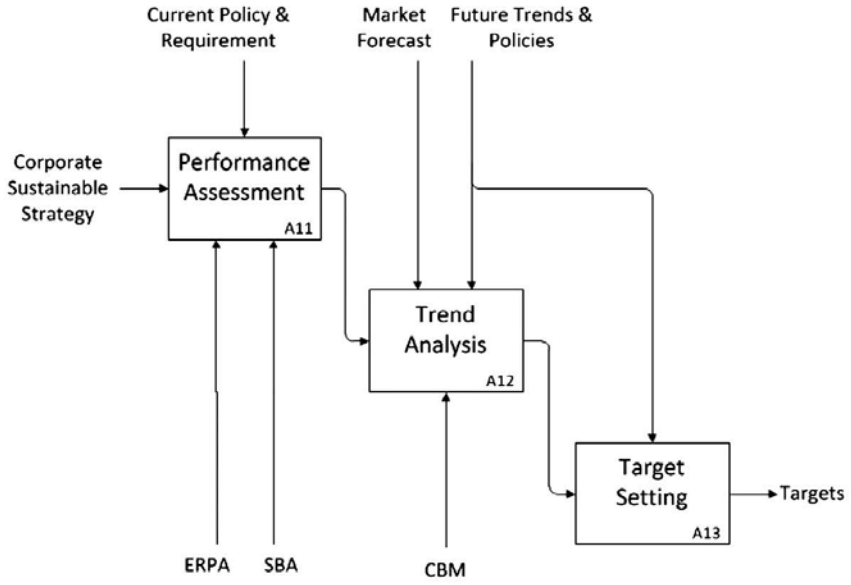

Figure 6. Strategic positioning tool.

international shipment would require improvements in both the design and the supply network system.

5.1.2. Distinguish product's trends & trajectory

Forecasting methodologies can be applied to determine the future social and environmental performances of the products. The performance trends and targets are plotted onto CBA in Figure 4. The performance trends indicate that current existing development in design will bring the toys down in terms of environmental impacts. For the sensory blocks, it is the possibility of incorporating flashing electronic lights. The two battery operated toys are going to add new sophisticated features that required more battery powers and capacitors; features such as a voice recording and processing element.

5.1.3. Outline performance targets

New targets are set for future products (re)development. These targets are set based on information of future legislative requirements and expectations for social and environmental improvements. The targets are set with the urgency and priority in mind. In this case, all toys are performing relatively well environmentally, therefore their targets mostly aim to improve the societal benefits. For the two battery-operated toys, the efforts required to improve the environmental scores are accounted for, hence the shorter targets for improvements in societal benefits.

5.2. Stage two – tactical planning

The tactical stage aims to translate newly set targets into a clear design brief for product development. It consists of three steps that will utilise the CBM. Firstly, the targets are to be examined in order to determine priorities and time scale for any actions. Secondly, suitable tactical options are listed and chosen for achieving the targets. The options should be chosen in the light of the information of timescale and priorities determined in the previous step.

Lastly, a design brief should be generated for the design team. This brief should embody the tactical options that were chosen. The overall processes are illustrated in Figure 7.

5.2.1. Analysing the targets and outlining tactical options

The targets set in the strategic planning stage provides an objective or a goal to be achieved, however there are no indications of timing and priorities when multiple products are involved in the decision-making process. There are multiple products and product lines in even SMEs, and it is essential to determine priorities and time scale along with the targets for sustainability performances. This is because of the fast and unpredictable nature of the industry and its market trends. In order to determine time scale and priorities, CBM and a Boston matrix are used for visualising and comparing the products on both matrices (Boston Consulting Group, 1970).

With high market share and slow or stagnating market growth, the singing and dancing soft toy is in its second year of sales. This makes it a 'cash cow' in a Boston matrix. Considering that sales are likely to decrease slowly in the following years, it is sensible to reduce the batches or stop sales all together instead of committing valuable time and resources to improve a finishing product. The pull along toy is a relatively new product on the market, with spectacular market growth and share, this means that it would be better to improve the design for better societal benefits. However, the environmental impacts also need to be addressed as it is very near the benchmark line for environmental impacts. The sensory blocks have low market share due to its niche market, but it has shown a good and steady market growth from increasing awareness from parenting websites and general mindfulness for environmentally friendly toys. It would be sensible to improve its design for societal benefits.

5.2.2. Outlining design brief

For redesigning options, a design brief should be generated for designers and manufacturing engineers to follow. The brief should be a clear statement that is instructive for achieving

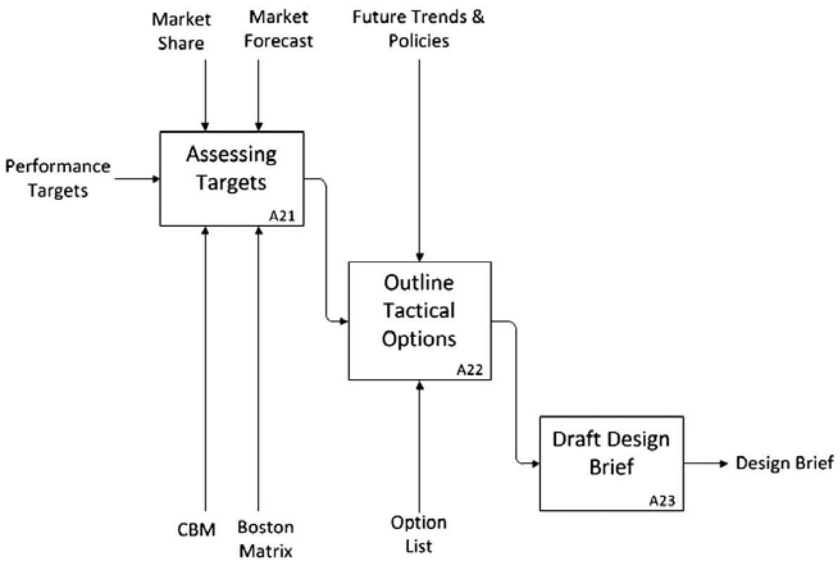

Figure 7. Tactical planning tool.

targets; however, it should not be specific so that there is room for creativity and innovation. The design brief should embody the targets that were set in strategic phase and should give clear indication of what to achieve. For both the sensory blocks and pull along toys, societal beneficial features need to be added or enhanced. This would mean aims for the toys. The pairwise comparisons results can be used as a guide. And that means improving the designs in the sensory and physical play types mostly and features that would provide a constructive play opportunities.

5.3. Stage three – operational design

The operational design stage only applies where design or redesigning was selected as the tactical option. The processes involved are depicted in Figure 8 along with the methods, tools and information that are required for each stage. The design process follows a well-established, widely used methodology of design; it starts with identifying needs and formulating a specification for the design where the needs are fulfilled. In this case, societal benefits will be highlighted as one of the more important needs. CBM can be used to quickly assess the specification to see whether the product described in the specification is going to perform to the brief drafted in the tactical stage and the targets set in the strategic stage. Design concepts are generated in accordance to the specification, where detailed design and prototypes are made. Quality function deployment methodology can be applied to ensure that the specification answers all the needs listed. Once again, the concepts, detailed design and prototypes can all be measured in CBM to ensure the social and environmental elements are properly and thoroughly considered. The final design put forward for manufacturing can be evaluated with performance data and put into CBM for a detailed assessment to confirm whether the final products are performing to the targets set in the strategic stage.

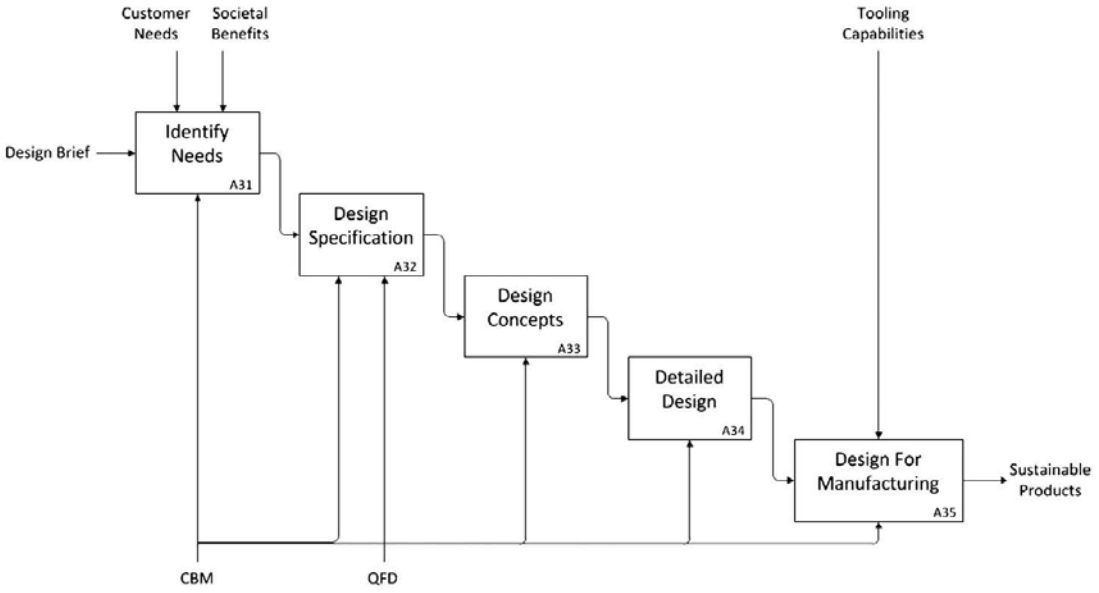

Figure 8. Operational design tool.

6. Discussion and conclusion

Current sustainability LCA methods primarily consider the negative impacts, and to a lesser degree the positive impacts, of a product over its life cycle. However these impacts are associated with the resources used in delivering these functions rather than the benefits derived from the functions themselves. How well a function is delivered and the benefit of that function are not generally considered in sustainable product assessment. It is proposed that in a resource constrained future, choices will have to be made as to which products are manufactured based on their value/benefit to society. This assertion led to an investigation of existing product assessment methods which identified a lack of capability in defining and quantifying positive societal impacts both a product and business level. Prior methods accounted positive impacts by avoiding or reducing negative impacts, instead of creating and enhancing positive social values. Based on the findings of this review a framework for incorporating societal benefits into sustainable product design was developed. This framework provides a systematic approach to encompassing societal benefit considerations into a company's product portfolio management process and ultimately its products.

A key activity in the first stage of the framework is the need to conduct a societal benefit assessment of individual products. The initial methodology for achieving this was developed within the framework however it became clear that a 'product category' assessment method would need to be developed to support this process. An assessment method was developed for toys aimed at 2–3 year olds that helps managers to quantify their products' positive impacts on this societal group. Whilst the initial method provides a quantitative result, the inputs used to achieve this have been determined through a largely qualitative process; its accuracy and objectivity have been enhanced through the use of AHP and other statistical methods. It is clear that whilst the initial findings and results are encouraging more work, including comparing the repeatability of the assessments, is needed to validate this approach.

The tool developed to support decision-making and strategic target settings for toy manufacturing and design helps to ensure a successful translation of the strategies from initial design brief to final product. Data obtained from the environmental and societal benefit assessments are compared and graphically presented within the tool to provide a simple and effective representation of the company's current position and trajectory that enables future sustainability targets, objectives and actions to be realistically set. The accuracy and effectiveness of the tool is dependent on the quality of the data input however the transparent application of this data would allow anomalies to be easily identified and investigated. Also whilst the tool supports the decision-making process it does not replace it and the final business outcomes will be dependent on the decisions taken.

The case study presented in the paper provides a clear demonstration of how the framework, method and tool are applied in a specific scenario. However it does not validate or measure the effectiveness of the tool and accuracy of the result. Due to the qualitative approach used to obtain the assessment metrics, weightings and scores, further case studies will need to be conducted in order to achieve a reliable measure of the tools success.

6.1. Limitations of research

As identified within the previous section, one of the biggest limitations of this approach is the ability to assess the societal benefits of product accurately. The accuracy of results

from the assessment method and the decision support tool depends on the appropriateness of scoring, measuring metrics, and weighting methods. These determine the ability to convert subjective data into quantitative and objective outcomes. Attempts have been made to address this limitation by combining expertise (in early child development and child psychology) with statistical processes to mitigate bias in the assessment. However, the effectiveness of these measures can only be determined through multiple case studies and the consistency of the results.

6.2. *Further work*

- More expert comments and opinions are required for AHP importance.
- Experts opinions in classification of play types scores into play benefits. This will address the assessment bias to toys with multiple features.
- The SBA results should be formally scrutinised against other results for verification of SBA.
- A detail case study is currently being carried out for validation of the tools for supporting design improvements for managers.

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Appendix 4 – Societal Benefit Assessment Method

Introduction

This appendix provides details of the SBA method that have been used within the assessment example described in Chapter 8. The pairwise comparisons method and calculation is presented in A4.1. The full scoring criteria for each play type is presented in A4.2

A4.1 The Play type pairwise comparison process

A4.2 The Scoring Criteria for each play type

A4.1 The Play type pairwise comparison process

Reciprocal Matrix

	Sensory	Construction	Challenge	Fantasy	Social Play	Solitary Play	Free Play	Play with Rules	Mental	Physical
Sensory	1.00	3.00	5.00	6.00	9.00	7.00	5.00	8.00	4.00	2.00
Construction	0.33	1.00	3.00	4.00	7.00	6.00	2.00	8.00	2.00	0.50
Challenge	0.20	0.33	1.00	2.00	8.00	3.00	0.50	3.00	0.20	0.14
Fantasy	0.17	0.25	0.50	1.00	6.00	2.00	0.25	2.00	0.50	0.14
Social Play	0.11	0.14	0.13	0.17	1.00	0.20	0.14	0.33	0.13	0.11
Solitary Play	0.14	0.17	0.33	0.50	5.00	1.00	0.20	2.00	0.50	0.13
Free Play	0.20	0.50	2.00	4.00	7.00	5.00	1.00	2.00	0.50	0.50
Play with Rules	0.13	0.13	0.33	0.50	3.00	0.50	0.50	1.00	0.17	0.13
Mental	0.25	0.50	5.00	2.00	8.00	2.00	2.00	6.00	1.00	0.50
Physical	0.50	2.00	7.00	7.00	9.00	8.00	2.00	8.00	2.00	1.00
Sum	**3.029**	**8.018**	**24.292**	**27.167**	**63.000**	**34.700**	**13.593**	**40.333**	**10.992**	**5.147**

Normalised Relative Weight

	Sensory	Construction	Challenge	Fantasy	Social Play	Solitary Play	Free Play	Play with Rules	Mental	Physical	
Sensory	0.330	0.374	0.206	0.221	0.143	0.202	0.368	0.198	0.364	0.389	
Construction	0.110	0.125	0.123	0.147	0.111	0.173	0.147	0.198	0.182	0.097	
Challenge	0.066	0.042	0.041	0.074	0.127	0.086	0.037	0.074	0.018	0.028	
Fantasy	0.055	0.031	0.021	0.037	0.095	0.058	0.018	0.050	0.045	0.028	
Social Play	0.037	0.018	0.005	0.006	0.016	0.006	0.011	0.008	0.011	0.022	
Solitary Play	0.047	0.021	0.014	0.018	0.079	0.029	0.015	0.050	0.045	0.024	
Free Play	0.066	0.062	0.082	0.147	0.111	0.144	0.074	0.050	0.045	0.097	
Play with Rules	0.041	0.016	0.014	0.018	0.048	0.014	0.037	0.025	0.015	0.024	
Mental	0.083	0.062	0.206	0.074	0.127	0.058	0.147	0.149	0.091	0.097	
Physical	0.165	0.249	0.288	0.258	0.143	0.231	0.147	0.198	0.182	0.194	
Sum	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**TRUE**

Principal Eigen Value				
λmax	=	11.1448251		
Consistency Index				
CI	=	λmax	-	n
		n	-	1
CI	=	11.14	-	10
		10	-	1
CI	=	0.1272		

Consistency Ratio		
CR	=	CI
		RI
CR	=	0.127203
		1.49
CR	=	0.085371

Normalised Principal Eigen Vector			
Priority Vector		normalised priority	
0.2794276		100%	Sensory
0.1414117		51%	Construction
0.0592945		21%	Challenge
0.0437697		16%	Fantasy
0.0139152		5%	Social Play
0.0342337		12%	Solitary Play
0.0878956		31%	Free Play
0.0252041		9%	Play with Rules
0.1092991		39%	Mental
0.2055488		74%	Physical

A4.2 The Scoring Criteria for each play type

Play Type	Score	Performance Criteria
Sensory Play	2	The toy can capture the playing child's attention with one type of sensory play.
	4	The toy can capture the playing child's attention with more than one type of sensory plays.
	6	In addition to caption the playing child's attention with more than one type of sensory plays, the toy should be able to sustain the child's interest for a longer period.
	8	Rather than capturing the child's attention and sustaining his/her interest, this toy should be engaging and captivating. It should be able to provide opportunities to explore the child's use of senses.
	10	The toy should be able to do all the above with a seamless integration of all the different sensory plays. It would provide an engaging and captivating playing experience in which the child would be encouraged to explore his/her senses and engage with his/her surroundings through the toy.
Construction Play	1	The toy encourages the playing child to make and create things.
	5	The toy encourages the playing child to make and create things with same simple parts
	10	The toy has different pieces and parts that encourages more complex constructions.
Fantasy Play	2	The toy encourages role-play, make believe, and/or pretence activities.
	4	The toy provides a foundation for role-play, make believe, and/or pretence activities
	6	The toy has elements that provides a foundation for role-play, make believe, and/or pretence activities
	8	The toy has elements, structure, and background that provides a foundation for role-play, make believe, and/or pretence activities
	10	The toy has elements, structure, and background that provides a foundation for role-play, make believe, and/or pretence activities that encourages social interaction and simulation.
Challenge Play	2	The toy provides opportunities to test the playing child's ability.
	4	The toy provides opportunities to test the playing child's ability, but does not drive him/her away for being too difficult.
	6	The toy provides opportunities to test the playing child's physical and mental ability, but does not drive him/her away for being too difficult.
	8	The toy provides opportunities to test the playing child's physical and mental ability, it should be up to a reasonable difficulty and does that drive him/her away.
	10	The toy provides opportunities to test the playing child's physical and mental ability. It should encourage different approaches to solve problems, and be up to a reasonable difficulty that does not drive him/her away.

Play Type	Score	Performance Criteria
Social Play	2	The toy encourages social activities - mimicking.
	4	The toy encourages social interactions and communication - language or nonverbal interaction.
	8	The toy encourages group social interactions and communication with aims.
	10	The toy encourages team work.
Free Play	2	The toy's play is free but it has structure and background.
	4	The toy's play is free but it has certain backgrounds like characters and figures.
	8	The toy's play is free but it has elements of restrain such as buttons and other features.
	10	The toy's play is completely free of any restraining features.
Play with rules	2	Guidelines are provided for the playing child.
	4	The toy provides structured play with guidelines within a set framework.
	6	The toy provides loose rules that can be negotiated or allows freedom to interpret and modify.
	8	The toy provides rule with little rooms to interpret and modify.
	10	The toy has a clear set of rigid rules, and there are no rooms for interpretation and compromise.
Mental Play	2	The toy encourages thinking.
	4	The toy encourages sequential thinking and casual reasoning.
	6	The toy encourages structured thinking and reasoning.
	8	The toy encourages structured thinking and reasoning based on a conceptual logical framework.
	10	The toy encourages structured thinking and reasoning based on a conceptual logical framework. It also encourages alternative scenario simulations.
Physical Play	2	The toy encourages physical activities.
	4	The toy encourages gross or fine motor exercises.
	6	The toy encourages both gross and fine motor exercises.
	8	The toy helps develop control.
	10	The toy helps develop strength and control.

Appendix 5 – Supporting Data for Case Studies

February 6, 2017

Hasbro Reports First $5 Billion Revenue Year with Growth in Revenue, Operating Profit and Net Earnings for Full-Year 2016

Board of Directors Increases Quarterly Dividend 12%, or $0.06 per share, to $0.57 per share

Full-Year 2016

- **2016 full-year net revenues of $5.02B increased 13%, including a negative $61.0 million impact of foreign exchange; Revenues grew 14% excluding the negative impact of foreign exchange;**
- **2016 revenues grew in all major operating segments: 15% in the U.S. and Canada segment; 11% in the International segment; and 8% in the Entertainment and Licensing segment;**
- **Games category revenues increased 9%; Revenues also grew in both the Girls and Boys categories; Franchise Brand revenues grew 2% and Partner Brand revenues increased 28%;**
- **2016 Operating profit increased 14% to $788.0M; Net earnings increased 22% to $551.4 million or $4.34 per diluted share;**
- **$774.9 million in operating cash flow generated during the year; Year-end cash and cash equivalents of $1.28B; Inventories flat year-over-year;**
- **Company returned $400.2 million to shareholders in 2016; $248.9 million in dividends and $151.3 million in share repurchases.**

Fourth Quarter 2016

- **Fourth Quarter net revenues increased 11% to $1.63 billion; Net earnings increased 10% to $192.7 million, or $1.52 per diluted share.**

PAWTUCKET, R.I.--(BUSINESS WIRE)-- **Hasbro, Inc.** (NASDAQ: HAS) today reported financial results for the full-year and fourth quarter 2016. Net revenues for the full-year 2016 increased 13% to $5.02 billion versus $4.45 billion in 2015. Excluding a negative $61.0 million impact from foreign exchange, 2016 revenues increased 14%.

As reported net earnings for the full-year 2016 increased 22% to $551.4 million, or $4.34 per diluted share, compared to $451.8 million, or $3.57 per diluted share in 2015. Adjusted net earnings for the full-year 2016 were $566.1 million, or $4.46 per diluted share. Adjusted 2016 earnings exclude a pre-tax $32.9 million, or $0.12 per diluted share, non-cash fourth quarter goodwill impairment charge related to Backflip Studios. Adjusted full-year 2016 net earnings compares to 2015 adjusted net earnings of $445.0 million, or $3.51 per diluted share, which exclude a pre-tax gain of $9.6 million from the sale of the Company's manufacturing operations in East Longmeadow, MA and Waterford, Ireland.

"Hasbro's global team delivered a tremendous 2016. We reached the $5 billion revenue mark for the first time in company history, we improved profitability and we invested to grow Hasbro over the long-term while increasing our dividend and share repurchase levels," said Brian Goldner, Hasbro's Chairman, President and Chief Executive Officer. "Hasbro's foresight to build brands led by storytelling, consumer insights and innovation, combined with the relentless execution of our Brand Blueprint including investments in entertainment and digital gaming, is driving our business and creating long-term strategic differentiators for Hasbro. We are well positioned for a successful 2017 and the continued advancement of Hasbro's brand-building capabilities for years to come."

"Our strong top line performance continued in the fourth quarter and we profitably grew Hasbro throughout the year," said Deborah Thomas, Hasbro's Chief Financial Officer. "Looking ahead, we are very well positioned to support our business. We continue investing in our industry-leading brands, our differentiated capabilities around the Brand Blueprint and in our systems to support long-term, cost efficient business growth. We ended the year with $1.28 billion in cash, inventories in line with last year, and we paid out $400 million to shareholders through dividends and share repurchases."

Fourth Quarter 2016 Financial Results

Fourth quarter 2016 net revenues increased 11% to $1.63 billion compared to $1.47 billion in 2015. Excluding a negative $11.9 million impact from foreign exchange, fourth quarter 2016 revenues increased 12%.

As reported net earnings for the fourth quarter 2016 increased 10% to $192.7 million, or $1.52 per diluted share, compared to $175.8 million, or $1.39 per diluted share in 2015. Adjusted net earnings for the fourth quarter 2016 were $207.4 million, or $1.64 per diluted share, excluding a pre-tax $32.9 million, or $0.12 per diluted share, non-cash fourth quarter goodwill impairment charge related to Backflip Studios.

Full-Year 2016 Major Segment Performance

	Net Revenues ($ Millions)			Operating Profit ($ Millions)		
	FY 2016	*FY 2015*	*% Change*	*FY 2016*	*FY 2015*	*% Change*
U.S. and Canada	$2,559.9	$2,225.5	+15%	$522.3	$430.7	+21%
International	$2,194.7	$1,971.9	+11%	$294.5	$255.4	+15%
Entertainment and Licensing	$265.2	$244.7	+8%	$49.9	$76.9	-35%

Note: Full-year 2016 Entertainment and Licensing segment operating profit includes a fourth quarter 2016 non-cash goodwill impairment charge. The impact of that charge and the impact on the fourth quarter and full-year 2015 segment operating profit from the sale of manufacturing operations is outlined in the attached schedule "Net Earnings and Earnings per Share Excluding Goodwill Impairment and Gain on Sale of Manufacturing Operations."

Full-year 2016 U.S. and Canada segment net revenues increased 15% to $2.56 billion compared to $2.23 billion in 2015. Growth in the Girls, Games and Boys categories offset a decline in the Preschool category. The U.S. and Canada segment reported operating profit growth of 21% to $522.3 million, or 20.4% of net revenues, compared to $430.7 million, or 19.4% of net revenues in 2015.

International segment net revenues increased 11% to $2.19 billion compared to $1.97 billion in 2015, behind growth in all four product categories: Girls, Preschool, Games and Boys. On a regional basis, Europe revenues increased 14%, Latin America grew 9% and Asia Pacific was up 6%. Emerging markets increased 9%. Excluding an unfavorable $58.4 million impact of foreign exchange, net revenues in the International segment grew 14%, increasing 15% in Europe, 18% in Latin America and 7% in Asia Pacific. Emerging markets increased approximately 12% absent the impact of foreign exchange. International segment operating profit increased 15% to $294.5 million, or 13.4% of revenues, compared to $255.4 million, or 13.0% of net revenues.

Entertainment and Licensing segment net revenues increased 8% to $265.2 million compared to $244.7 million in 2015. Full-year gains were driven by growth in Consumer Products and Digital Gaming, as well as the addition of Boulder Media. As reported operating profit was $49.9 million compared to $76.9 million in 2015. Adjusted operating profit was $82.7 million, which excludes a pre-tax $32.9 million, or $0.12 per diluted share, non-cash fourth quarter goodwill impairment charge related to Backflip Studios.

Fourth Quarter and Full-Year 2016 Product Category Performance

	Net Revenues ($ Millions)					
	Q4 2016	*Q4 2015*	*% Change*	*FY 2016*	*FY 2015*	*% Change*
Boys	$552.3	$569.8	-3%	$1,849.6	$1,775.9	+4%
Games	$518.7	$465.8	+11%	$1,387.1	$1,276.5	+9%
Girls	$394.2	$258.8	+52%	$1,193.9	$798.2	+50%
Preschool	$164.8	$170.9	-4%	$589.2	$596.8	-1%

Boys category revenues for the full-year 2016 increased 4% to $1.85 billion. Revenue growth for the year was driven by gains in Franchise Brand NERF, as well as shipments of YO-KAI WATCH.

Games category revenues for the year increased 9% to $1.39 billion. Hasbro's differentiated gaming portfolio drove growth across gaming formats, including face-to-face gaming, off-the-board gaming and digital gaming. Franchise Brand MAGIC: THE GATHERING revenues increased for the eighth straight year, along with growth in PIE FACE, DUEL MASTERS, SIMON, BOP-IT and the successful launch of the SPEAK-OUT game.

Girls category revenues in 2016 grew 50% to a record $1.19 billion. The category benefited from shipments of Hasbro's line of DISNEY PRINCESS and DISNEY FROZEN fashion and small dolls, the successful launch of DREAMWORKS' TROLLS and significant growth from BABY ALIVE. Additional revenue growth came from Hasbro brands including FURREAL FRIENDS and EASY-BAKE OVEN products.

Preschool category revenues declined 1% to $589.2 million in 2016. The fifth consecutive year of revenue growth in Franchise Brand PLAY-DOH was more than offset by declines in PLAYSKOOL HEROES and core PLAYSKOOL items.

Beginning with the first quarter 2017 earnings, Hasbro will report its revenue by brand portfolio: Franchise Brands, Partner Brands, Hasbro Gaming and Emerging Brands. At that time, the Company will cease providing a revenue breakdown by product category: Boys, Games, Girls and Preschool. Fourth quarter and full-year 2016 and 2015 brand portfolio revenue is available in the following table.

Fourth Quarter and Full-Year 2016 Brand Portfolio Performance

	Net Revenues ($ Millions)					
	Q4 2016	*Q4 2015*	*% Change*	*FY 2016*	*FY 2015*	*% Change*
Franchise Brands	$685.6	$669.0	+2%	$2,327.7	$2,285.4	+2%
Partner Brands	$433.7	$375.4	+16%	$1,412.8	$1,101.3	+28%
Hasbro Gaming*	$356.9	$291.1	+23%	$813.4	$662.3	+23%
Emerging Brands	$153.7	$129.9	+18%	$466.0	$398.5	+17%

*Hasbro's total gaming category, including all gaming revenue, most notably MAGIC: THE GATHERING and MONOPOLY, totaled $518.7 million for the fourth quarter 2016, up 11%, and $1,387.1 million, up 9%, for the full year 2016. Hasbro believes its gaming portfolio is a competitive differentiator and views it in its entirety.

Dividend and Share Repurchase

In 2016, Hasbro returned $400.2 million to shareholders including $248.9 million in cash dividends. Hasbro's Board of Directors has declared a quarterly cash dividend of $0.57 per common share. This represents an increase of $0.06 per share, or 12%, from the previous quarterly dividend of $0.51 per common share. The dividend will be payable on May 15, 2017 to shareholders of record at the close of business on May 1, 2017.

In 2016, Hasbro repurchased 1.89 million shares at a total cost of $151.3 million and an average price of $79.86 per share. At year end, $328.0 million remained available in the current share repurchase authorization.

Conference Call Webcast

Hasbro will webcast its fourth quarter and full-year 2016 earnings conference call at 8:30 a.m. Eastern Time today. To listen to the live webcast and access the accompanying presentation slides, please go to http://investor.hasbro.com. The replay of the call will be available on Hasbro's web site approximately 2 hours following completion of the call.

Hasbro (NASDAQ: HAS) is a global play and entertainment company committed to *Creating the World's Best Play Experiences*. From toys and games to television, movies, digital gaming and consumer products, Hasbro offers a variety of ways for audiences to experience its iconic brands, including NERF, MY LITTLE PONY, TRANSFORMERS, PLAY-DOH, MONOPOLY, LITTLEST PET SHOP and MAGIC: THE GATHERING, as well as premier partner brands. The Company's Hasbro Studios and its film label, Allspark Pictures, are building its brands globally through great storytelling and content on all screens. Through its commitment to corporate social responsibility and philanthropy, Hasbro is helping to make the world a better place for children and their families. Learn more at www.hasbro.com, and follow us on Twitter (@Hasbro & @HasbroNews) and Instagram (@Hasbro).

Certain statements in this release contain "forward-looking statements" within the meaning of the Private Securities Litigation Reform Act of 1995. These statements include expectations concerning the Company's potential performance in the future, including with respect to anticipated future benefits from investments in the Company's business and strategic efforts to grow the Company's brand portfolio and content delivery over the longer-term, and the Company's ability to achieve its other financial and business goals and may be identified by the use of forward-looking words or phrases. The Company's actual actions or results may differ materially from those expected or anticipated in the forward-looking statements due to both known and unknown risks and uncertainties. Specific factors that might cause such a difference include, but are not limited to: (i) the Company's ability to design, develop, produce, manufacture, source and ship products on a timely and cost-effective basis, as well as interest in and purchase of those products by retail customers and consumers in quantities and at prices that will be sufficient to profitably recover the Company's costs; (ii) downturns in economic conditions affecting the Company's markets which can negatively impact the Company's retail customers and consumers, and which can result in lower employment levels, lower consumer disposable income and spending, including lower spending on purchases of the Company's products; (iii) other factors which can lower discretionary consumer spending, such as higher costs for fuel and food, drops in the value of homes or other consumer assets, and high levels of consumer debt; (iv) potential difficulties or delays the Company may experience in implementing cost savings and efficiency enhancing initiatives; (v) other economic and public health conditions or regulatory changes in the markets in which the Company and its customers and suppliers operate which could create delays or increase the Company's costs, such as

higher commodity prices, labor costs or transportation costs, or outbreaks of disease; (vi) currency fluctuations, including movements in foreign exchange rates, which can lower the Company's net revenues and earnings, and significantly impact the Company's costs; (vii) the concentration of the Company's customers, potentially increasing the negative impact to the Company of difficulties experienced by any of the Company's customers or changes in their purchasing or selling patterns; (viii) consumer interest in and acceptance of the Discovery Family Channel, and content created by Hasbro Studios and Allspark Pictures; (ix) the inventory policies of the Company's retail customers, including retailers' potential decisions to lower their inventories, even if it results in lost sales, as well as the concentration of the Company's revenues in the second half of the year, which coupled with reliance by retailers on quick response inventory management techniques increases the risk of underproduction of popular items, overproduction of less popular items and failure to achieve compressed shipping schedules; (x) delays, increased costs or difficulties associated with any of our or our partners' planned digital applications or media and entertainment initiatives; (xi) work disruptions, which may impact the Company's ability to manufacture or deliver product in a timely and cost-effective manner; (xii) the bankruptcy or other lack of success of one of the Company's significant retailers which could negatively impact the Company's revenues or bad debt exposure; (xiii) the impact of competition on revenues, margins and other aspects of the Company's business, including the ability to offer Company products which consumers choose to buy instead of competitive products, the ability to secure, maintain and renew popular licenses and the ability to attract and retain talented employees; (xiv) concentration of manufacturing for many of the Company's products in the People's Republic of China and the associated impact to the Company of social, economic or public health conditions and other factors affecting China, the movement of products into and out of China, the cost of producing products in China and exporting them to other countries; (xv) the risk of product recalls or product liability suits and costs associated with product safety regulations; (xvi) changes in laws or regulations in the United States and/or in other major markets in which the Company operates, including, without limitation, with respect to taxes, tariffs or product safety, which may increase the Company's product costs and other costs of doing business, and reduce the Company's earnings, (xvii) failure to realize the planned benefits from any investments or acquisitions made by the Company, (xviii) the impact of other market conditions, third party actions or approvals and competition which could reduce demand for the Company's products or delay or increase the cost of implementation of the Company's programs or alter the Company's actions and reduce actual results; (xix) the impact of litigation or arbitration decisions or settlement actions; and (xx) other risks and uncertainties as may be detailed from time to time in the Company's public announcements and Securities and Exchange Commission ("SEC") filings. The Company undertakes no obligation to make any revisions to the forward-looking statements contained in this release or to update them to reflect events or circumstances occurring after the date of this release.

This press release includes non-GAAP financial measures as defined under SEC rules. Other companies may calculate these measures differently. These non-GAAP financial measures include EBITDA. EBITDA represents net earnings attributable to Hasbro, Inc. excluding net loss attributable to noncontrolling interests, interest expense, income taxes, depreciation and amortization. As required by SEC rules, we have provided reconciliation on the attached schedule of this measure to the most directly comparable GAAP measure. Management believes that EBITDA is one of the appropriate measures for evaluating the operating performance of the Company because it reflects the resources available for strategic opportunities including, among others, to invest in the business, strengthen the balance sheet, and make strategic acquisitions.

The press release also includes certain of the Company's 2016 and 2015 cost and expenses, income tax expense, net earnings and diluted earnings per share excluding the impact of the non-cash goodwill impairment charge and the gain on the sale of the Company's manufacturing operations in East Longmeadow, MA and Waterford, Ireland. Management believes that the presentation excluding the impact of the goodwill impairment charge and the gain on the sale of the manufacturing operations provides a useful measure of the underlying operations of the Company. In addition, the press release includes the increases in the Company's International segment and certain region net revenues excluding the impact of changes in exchange rates. The impact of changes in exchange rates is calculated by translating the 2016 local currency revenues at 2015 actual rates and comparing this amount to the 2016 reported revenues. Management believes that the presentation excluding the impact of exchange rate changes provides information that is helpful to an investor's understanding of the underlying business performance absent exchange rate fluctuations which are beyond the Company's control. These measures should be considered in addition to, not as a substitute for, or superior to, net earnings or other measures of financial performance prepared in accordance with GAAP as more fully discussed in the Company's financial statements and filings with the SEC. As used herein, "GAAP" refers to accounting principles generally accepted in the United States of America.

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HASBRO, INC.
CONDENSED CONSOLIDATED BALANCE SHEETS
(Unaudited)

(Thousands of Dollars)

	Dec. 25, 2016	Dec. 27, 2015
ASSETS		
Cash and Cash Equivalents	$ 1,282,285	$ 976,750

Accounts Receivable, Net	1,319,963	1,217,850
Inventories	387,675	384,492
Other Current Assets	237,684	286,506
Total Current Assets	3,227,607	2,865,598
Property, Plant and Equipment, Net	267,398	237,527
Other Assets	1,596,361	1,617,592
Total Assets	$ 5,091,366	$ 4,720,717

LIABILITIES, REDEEMABLE NONCONTROLLING INTERESTS AND SHAREHOLDERS' EQUITY

Short-term Borrowings	$ 172,582	$ 164,563
Current Portion of Long-term Debt	349,713	-
Payables and Accrued Liabilities	1,095,564	900,084
Total Current Liabilities	1,617,859	1,064,647
Long-term Debt	1,198,679	1,547,115
Other Liabilities	389,388	404,883
Total Liabilities	3,205,926	3,016,645
Redeemable Noncontrolling Interests	22,704	40,170
Total Shareholders' Equity	1,862,736	1,663,902
Total Liabilities, Redeemable Noncontrolling Interests and Shareholders' Equity	$ 5,091,366	$ 4,720,717

HASBRO, INC.
CONSOLIDATED STATEMENTS OF OPERATIONS
(Unaudited)

	Quarter Ended				Year Ended			
(Thousands of Dollars and Shares Except Per Share Data)	Dec. 25, 2016	% Net Revenues	Dec. 27, 2015	% Net Revenues	Dec. 25, 2016	% Net Revenues	Dec. 27, 2015	% Net Revenues
Net Revenues	$1,629,940	100.0%	$1,465,354	100.0%	$5,019,822	100.0%	$4,447,509	100.0%
Costs and Expenses:								
Cost of Sales	634,572	38.9%	554,750	37.9%	1,905,474	38.0%	1,677,033	37.7%
Royalties	135,851	8.3%	149,137	10.2%	409,522	8.2%	379,245	8.5%
Product Development	75,457	4.6%	68,645	4.7%	266,375	5.3%	242,944	5.5%
Advertising	147,992	9.1%	121,252	8.3%	468,940	9.3%	409,388	9.2%
Amortization of Intangibles	8,690	0.5%	8,392	0.6%	34,763	0.7%	43,722	1.0%
Program Production Cost Amortization	18,430	1.1%	12,637	0.9%	35,931	0.7%	42,449	1.0%
Selling, Distribution and Administration	353,791	21.7%	291,840	19.9%	1,110,769	22.1%	960,795	21.6%
Operating Profit	255,157	15.7%	258,701	17.7%	788,048	15.7%	691,933	15.6%
Interest Expense	25,142	1.5%	24,306	1.7%	97,405	1.9%	97,122	2.2%
Other (Income) Expense, Net	10,083	0.6%	3,058	0.2%	(1,846)	0.0%	(9,104)	-0.2%
Earnings								

before Income Taxes	219,932	13.5%	231,337	15.8%	692,489	13.8%	603,915	13.6%
Income Taxes	39,333	2.4%	56,943	3.9%	159,338	3.2%	157,043	3.5%
Net Earnings	180,599	11.1%	174,394	11.9%	533,151	10.6%	446,872	10.0%
Net Loss Attributable to Noncontrolling Interests	(12,126)	-0.7%	(1,369)	-0.1%	(18,229)	-0.4%	(4,966)	-0.1%
Net Earnings Attributable to Hasbro, Inc.	$ 192,725	11.8%	$ 175,763	12.0%	$ 551,380	11.0%	$ 451,838	10.2%
Per Common Share								
Net Earnings Attributable to Hasbro, Inc.								
Basic	$ 1.54		$ 1.41		$ 4.40		$ 3.61	
Diluted	$ 1.52		$ 1.39		$ 4.34		$ 3.57	
Cash Dividends Declared	$ 0.51		$ 0.46		$ 2.04		$ 1.84	
Weighted Average Number of Shares								
Basic	124,927		124,976		125,292		125,006	
Diluted	126,699		126,686		126,966		126,688	

HASBRO, INC.
CONDENSED CONSOLIDATED STATEMENTS OF CASH FLOWS
(Unaudited)
(Thousands of Dollars)

	Year Ended	
	Dec. 25, 2016	Dec. 27, 2015
Cash Flows from Operating Activities:		
Net Earnings	$ 533,151	$ 446,872
Non-cash Adjustments	284,221	232,702
Changes in Operating Assets and Liabilities	(42,499)	(127,129)
Net Cash Provided by Operating Activities	774,873	552,445
Cash Flows from Investing Activities:		
Additions to Property, Plant and Equipment	(154,900)	(142,022)
(Payments) Proceeds for Acquisitions and Dispositions	(12,436)	18,632
Other	28,945	19,743
Net Cash Utilized by Investing Activities	(138,391)	(103,647)
Cash Flows from Financing Activities:		
Net Proceeds from (Repayments of) Short-term Borrowings	8,978	(87,310)
Purchases of Common Stock	(150,075)	(87,224)
Stock-based Compensation Transactions	62,678	57,550
Dividends Paid	(248,881)	(225,797)

Other	(5,758)	(3,676)
Net Cash Utilized by Financing Activities	(333,058)	(346,457)
Effect of Exchange Rate Changes on Cash	2,111	(18,758)
Cash and Cash Equivalents at Beginning of Year	976,750	893,167
Cash and Cash Equivalents at End of Year	$ 1,282,285	$ 976,750

HASBRO, INC.
SUPPLEMENTAL FINANCIAL DATA
(Unaudited)

(Thousands of Dollars)	Quarter Ended			Year Ended		
	Dec. 25, 2016	Dec. 27, 2015	% Change	Dec. 25, 2016	Dec. 27, 2015	% Change
Major Segment Results						
U.S. and Canada Segment:						
External Net Revenues	$ 757,516	$ 690,821	10%	$ 2,559,907	$ 2,225,518	15%
Operating Profit	157,965	155,085	2%	522,287	430,707	21%
Operating Margin	20.9%	22.4%		20.4%	19.4%	
International Segment:						
External Net Revenues	757,740	690,757	10%	2,194,651	1,971,875	11%
Operating Profit	128,915	113,895	13%	294,497	255,365	15%
Operating Margin	17.0%	16.5%		13.4%	13.0%	
Entertainment and Licensing Segment:						
External Net Revenues	114,684	84,275	36%	265,205	244,685	8%
Operating Profit	16,509	36,778	-55%	49,876	76,868	-35%
Operating Margin	14.4%	43.6%		18.8%	31.4%	
International Segment Net Revenues by Major Geographic Region						
Europe	$ 499,397	$ 466,291	7%	$ 1,404,478	$ 1,236,846	14%
Latin America	155,689	128,232	21%	463,638	426,109	9%
Asia Pacific	102,654	96,234	7%	326,535	308,920	6%
Total	$ 757,740	$ 690,757		$ 2,194,651	$ 1,971,875	
Net Revenues by Product Category						
Boys	$ 552,287	$ 569,799	-3%	$ 1,849,645	$ 1,775,917	4%
Games	518,704	465,784	11%	1,387,077	1,276,532	9%
Girls	394,177	258,839	52%	1,193,877	798,240	50%
Preschool	164,772	170,932	-4%	589,223	596,820	-1%
Total Net Revenues	$ 1,629,940	$ 1,465,354		$ 5,019,822	$ 4,447,509	
Brand Portfolio Performance						
Franchise Brands	$ 685,611	$ 668,989	2%	$ 2,327,668	$ 2,285,414	2%
Partner Brands	433,719	375,377	16%	1,412,770	1,101,305	28%
Hasbro Gaming	356,918	291,123	23%	813,433	662,319	23%
Emerging Brands	153,692	129,865	18%	465,951	398,471	17%
Total Net Revenues	$ 1,629,940	$ 1,465,354		$ 5,019,822	$ 4,447,509	

Hasbro's total gaming category, including all gaming revenue, most notably MAGIC: THE GATHERING and MONOPOLY, totaled $518,704 for the fourth quarter of 2016, up 11%, from revenues of $465,784 for the fourth quarter of 2015. For the full year 2016, the total gaming business totaled $1,387,077, up 9%, from revenues of $1,276,532 for the full year 2015.

HASBRO, INC.
SUPPLEMENTAL FINANCIAL DATA
RECONCILIATION OF NON-GAAP FINANCIAL MEASURES
(Unaudited)
(Thousands of Dollars)

Net Earnings and Earnings per Share Excluding Goodwill Impairment and Gain on Sale of Manufacturing Operations

	Quarter Ended			
	Dec. 25, 2016	Diluted Per Share Amount	Dec. 27, 2015	Diluted Per Share Amount
Net Earnings Attributable to Hasbro, Inc., as Reported	$ 192,725	$ 1.52	$ 175,763	$ 1.39
Goodwill Impairment Charge	14,674	0.12	-	-
Gain on Sale of Manufacturing Operations	-	-	165	-
Net Earnings Attributable to Hasbro, Inc., as Adjusted	$ 207,399	$ 1.64	$ 175,928	$ 1.39

	Year Ended			
	Dec. 25, 2016	Diluted Per Share Amount	Dec. 27, 2015	Diluted Per Share Amount
Net Earnings Attributable to Hasbro, Inc., as Reported	$ 551,380	$ 4.34	$ 451,838	$ 3.57
Goodwill Impairment Charge	14,674	0.12	-	-
Gain on Sale of Manufacturing Operations	-	-	(6,885)	(0.05)
Net Earnings Attributable to Hasbro, Inc., as Adjusted	$ 566,054	$ 4.46	$ 444,953	$ 3.51

The line items impacted by the goodwill impairment charge and the gain on sale as well as these line items excluding these amounts as a percentage of revenues is as follows:

	As Reported	% Net Revenues	Less Goodwill Impairment Charge		Excluding Goodwill Impairment Charge	% Net Revenues
Quarter Ended December 25, 2016						
Selling, Distribution and Administration	$ 353,791	21.7%	$ (32,858)	(1)	$ 320,933	19.7%
Tax Expense	39,333	2.4%	8,327		47,660	2.9%
Net Loss Attributable to Noncontrolling Interests	(12,126)	-0.7%	9,857		(2,269)	-0.1%
Year Ended December 25, 2016						
Selling, Distribution and Administration	$ 1,110,769	22.1%	$ (32,858)	(1)	$ 1,077,911	21.5%
Tax Expense	159,338	3.2%	8,327		167,665	3.3%
Net Loss Attributable to Noncontrolling Interests	(18,229)	-0.4%	9,857		(8,372)	-0.2%

(1) This charge was recorded in the Entertainment and Licensing segment. Excluding this charge, operating profit and

margin for the segment for the quarter ended December 25, 2016 would have been $49,367 and 43.0%, respectively, and $82,734 and 31.2%, respectively, for the year ended December 25, 2016.

	As Reported	% Net Revenues	Less Gain on Sale of Manufacturing Operations		Excluding Gain on Sale of Manufacturing Operations	% Net Revenues
Quarter Ended December 27, 2015						
Selling, Distribution and Administration	$ 291,840	19.9%	$ -		$ 291,840	19.9%
Other (Income) Expense, Net	3,058	0.2%	(259)	(2)	2,799	0.2%
Tax Expense	56,943	3.9%	94		57,037	3.9%
Year Ended December 27, 2015						
Selling, Distribution and Administration	$ 960,795	21.6%	$ 3,061	(2)	$ 963,856	21.7%
Other (Income) Expense, Net	(9,104)	-0.2%	6,573		(2,531)	-0.1%
Tax Expense	157,043	3.5%	(2,749)		154,294	3.5%

(2) This gain (loss) was recorded in the corporate and eliminations segment.

	Quarter Ended		Year Ended	
Reconciliation of EBITDA	Dec. 25, 2016	Dec. 27, 2015	Dec. 25, 2016	Dec. 27, 2015
Net Earnings Attributable to Hasbro, Inc.	$ 192,725	$ 175,763	$ 551,380	$ 451,838
Net Loss Attributable to Noncontrolling Interests	(12,126)	(1,369)	(18,229)	(4,966)
Interest Expense	25,142	24,306	97,405	97,122
Income Taxes	39,333	56,943	159,338	157,043
Depreciation	30,380	25,212	119,707	111,605
Amortization of Intangibles	8,690	8,392	34,763	43,722
EBITDA	$ 284,144	$ 289,247	$ 944,364	$ 856,364

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Mattel Reports Full Year And Fourth Quarter 2016 Financial Results And Declares Quarterly Dividend

EL SEGUNDO, Calif., Jan. 25, 2017 /PRNewswire/ --

Full Year Highlights[1]

- Worldwide net sales down 4% as reported, and down 2% in constant currency; worldwide gross sales down 3% as reported, and flat in constant currency. Excluding Disney Princess®, worldwide gross sales up mid-single digits as reported, and up high-single digits in constant currency.
- Fisher-Price® worldwide gross sales up 2% as reported, and up 6% in constant currency; Wheels worldwide gross sales up 6% as reported, and up 11% in constant currency; Barbie® worldwide gross sales up 7% as reported, and up 9% in constant currency.
- Reported operating income of $519.2 million, compared to reported operating income of $540.9 million in the prior year; and adjusted operating income of $560.8 million, compared to adjusted operating income of $623.6 million in the prior year.
- Reported earnings per share of $0.92, compared to reported earnings per share of $1.08 in the prior year; and adjusted earnings per share of $1.06, compared to adjusted earnings per share of $1.27 in the prior year.

Fourth Quarter Highlights[1]

- Worldwide net sales down 8% as reported, and down 6% in constant currency; worldwide gross sales down 5% as reported, and down 1% in constant currency. Excluding Disney Princess, worldwide gross sales flat as reported, and up mid-single digits in constant currency.
- Fisher-Price worldwide gross sales down 3% as reported, and up 2% in constant currency; Wheels worldwide gross sales up 13% as reported, and up 18% in constant currency; Barbie worldwide gross sales down 2% as reported, and up 1% in constant currency.
- Reported operating income of $262.6 million, compared to reported operating income of $294.1 million in the prior year's fourth quarter; and adjusted operating income of $269.2 million, compared to adjusted operating income of $306.3 million in the prior year's fourth quarter.
- Reported earnings per share of $0.50, compared to reported earnings per share of $0.63 in the prior year's fourth quarter; and adjusted earnings per share of $0.52, compared to adjusted earnings per share of $0.65 in the prior year's fourth quarter.

Capital Deployment

- Board declared a 2017 first quarter cash dividend of $0.38 per share, which is flat compared to the first quarter of 2016.

Mattel, Inc. (NASDAQ: MAT) today reported full year and fourth quarter 2016 financial results.

"Our results were negatively impacted by a number of industry–wide challenges, including a significant U.S. toy category slowdown in the holiday period, and increased forex headwinds," said Christopher Sinclair, Chairman and CEO of Mattel. "And while our sales at retail remained strong, the slowdown triggered elevated retail promotional activity and decreased shipping, all of which had a significant impact on our gross margin."

Mr. Sinclair added, "Even against this difficult backdrop, our core brands continued to show solid growth, and our performance in key emerging markets like China was equally strong. And, importantly, we offset a substantial revenue gap from the loss of the Disney Princess license. Looking forward, we remain broadly optimistic about Mattel's performance in 2017 and beyond. Our core brands are strong and growing, we have a solid lineup of entertainment properties in the pipeline, and we are forging valuable relationships with key retail partners throughout the world."

For the year, reported worldwide net sales were down 4% as reported, and were down 2% in constant currency, versus the prior year. Worldwide gross sales were down 3% as reported, and were flat in constant currency. Reported operating income was $519.2 million, and adjusted operating income was $560.8 million. Reported earnings per share were $0.92, and adjusted earnings per share were

$1.06.

For the fourth quarter of 2016, net sales were down 8% as reported, and were down 6% in constant currency, versus the prior year. Worldwide gross sales were down 5% as reported, and were down 1% in constant currency. Reported operating income was $262.6 million, and adjusted operating income was $269.2 million. Reported earnings per share were $0.50, and adjusted earnings per share were $0.52.

Financial Overview

For the year, net sales in the North American Region, which consists of the United States, Canada and American Girl®, decreased by 2% as reported, and decreased by 1% in constant currency, versus the prior year. In the International Region, net sales decreased by 8% as reported, and decreased by 2% in constant currency. Gross sales in the North American Region decreased by 1% as reported and in constant currency. In the International Region, gross sales decreased by 6% as reported, and were up 1% in constant currency. Gross margin for the year decreased 240 basis points, driven mainly by the negative impact from changes in currency exchange rates. Reported other selling and administrative expenses for the year decreased $147.3 million and adjusted other selling and administrative expenses decreased $106.2 million, reflecting continuous cost improvement initiatives and lower incentive and equity compensation expenses. Reported operating income for the year was $519.2 million, compared to the prior year's reported operating income of $540.9 million. Adjusted operating income for the year was $560.8 million, compared to the prior year's adjusted operating income of $623.6 million. The Company delivered at the high end of its two-year, $300 million cost savings plan in 2016.

For the fourth quarter, net sales in the North American Region decreased by 7% as reported and in constant currency, versus the prior year's fourth quarter. In the International Region, net sales decreased by 10% as reported, and decreased by 2% in constant currency. Fourth quarter gross sales in the North American Region decreased by 5% as reported and in constant currency. In the International Region, gross sales decreased by 4% as reported, and were up 4% in constant currency. Gross margin for the quarter decreased 320 basis points, driven mainly by elevated discounting, and the negative impact from changes in currency exchange rates. Reported other selling and administrative expenses decreased $63.5 million; adjusted other selling and administrative expenses for the quarter decreased $57.9 million, reflecting continuous cost improvement initiatives and lower incentive and equity compensation expenses. Reported operating income for the quarter was $262.6 million, compared to the prior year's fourth quarter reported operating income of $294.1 million. Adjusted operating income for the quarter was $269.2 million, compared to the prior year's fourth quarter adjusted operating income of $306.3 million.

In the fourth quarter, Mattel's retail sales (POS) were on par with overall toy category retail sales in the U.S., excluding Disney Princesses.

For the year, net cash flows from operating activities were approximately $590 million, a decrease of approximately $145 million versus the prior year, primarily driven by higher working capital usage and lower net income. Cash flows used for investing activities were approximately $307 million, an increase of approximately $24 million versus the prior year, primarily driven by payments for acquisitions, partially offset by changes in foreign currency forward exchange contracts for the year. For the year, cash flows used for financing activities and other were approximately $306 million, compared to approximately $531 million in the prior year, primarily driven by proceeds from the issuance of long-term debt and higher short-term borrowings, partially offset by the repayment of maturing debt.

The Company's debt-to-total capital ratio as of December 31, 2016 was 49.2%.

Capital Deployment

The Board of Directors declared a 2017 first quarter cash dividend of $0.38 per share, which is flat compared to the first quarter of 2016. The dividend will be payable on March 3, 2017 to stockholders of record on February 16, 2017.

Sales by Brand

Mattel Girls and Boys Brands |

For the year, worldwide gross sales for Mattel Girls & Boys Brands were $3.19 billion, down 8% as reported, and down 5% in constant currency, versus the prior year. Worldwide gross sales for the Barbie brand were up 7% as reported, and up 9% in constant currency, versus the prior year. Worldwide gross sales for Other Girls brands, which includes Disney Princess and Monster High®, were down 52% as reported, and down 47% in constant currency, versus the prior year. Worldwide gross sales for the Wheels category, which includes the Hot Wheels® and Matchbox® brands, were up 6% as reported, and were up 11% in constant currency, versus the prior year. Worldwide gross sales for the Entertainment business, which includes Radica® and Games, were up 13% as reported, and were up 16% in constant currency, versus the prior year.

For the fourth quarter, worldwide gross sales for Mattel Girls & Boys Brands were $1.05 billion, down 7% as reported, and down 3% in constant currency, versus the prior year's fourth quarter. Worldwide gross sales for the Barbie brand were down 2% as reported, and up 1% in constant currency, versus the prior year's fourth quarter. Worldwide gross sales for Other Girls brands, which includes Disney Princess and Monster High, were down 41% as reported, and down 35% in constant currency, versus the prior year's fourth quarter. Worldwide gross sales for the Wheels category were up 13% as reported, and were up 18% in constant currency, versus the prior year's fourth quarter. Worldwide gross sales for the Entertainment business were flat as reported, and were up 2% in constant currency, versus the prior year's fourth quarter.

Fisher-Price Brands

For the year, worldwide gross sales for Fisher-Price Brands, which includes the Fisher-Price Core, Fisher-Price Friends and Power Wheels® brands, were $1.89 billion, up 2% as reported, and up 6% in constant currency, versus the prior year. Fourth quarter worldwide gross sales were $607.7 million, down 3% as reported, and up 2% in constant currency, versus the prior year's fourth quarter.

American Girl Brands

For the year, worldwide gross sales for American Girl Brands®, which offers American Girl-branded products directly to consumers, were $570.8 million, flat as reported and in constant currency, versus the prior year. Fourth quarter gross sales were $283.9 million, up 4% as reported, and up 5% in constant currency, versus the prior year's fourth quarter.

Construction and Arts & Crafts Brands

For the year, worldwide gross sales for Construction and Arts & Crafts Brands, which includes the MEGA BLOKS® and RoseArt® brands, were $377.6 million, up 7% as reported, and up 15% in constant currency, versus the prior year. Fourth quarter gross sales were $124.8 million, down 4% as reported, and up 1% in constant currency, versus the prior year's fourth quarter.

Conference Call and Live Webcast

At 6:00 p.m. (Eastern Time) today, Mattel will host a conference call with investors and financial analysts to discuss its 2016 full year and fourth quarter financial results. The conference call will be webcast on Mattel's Investor Relations website, http://investor.shareholder.com/mattel (http://investor.shareholder.com/mattel). To listen to the live call, log on to the website at least 10 minutes early to register, download and install any necessary audio software. An archive of the webcast will be available on the company's website for 90 days and may be accessed beginning approximately two hours after the completion of the live call. A telephonic replay of the call will be available beginning at 9:00 p.m. Eastern time the evening of the call until Wednesday, February 1, 2017, and may be accessed by dialing +1-404-537-3406. The passcode is 43079679.

Forward-Looking Statements

This press release contains forward-looking statements on a variety of matters. These forward-looking statements are based on currently available operating, financial, economic and other information, and are subject to a number of significant risks and uncertainties. A variety of factors, many of which are beyond our control, could cause actual future results to differ materially from those projected in the forward-looking statements. Some of these factors are described in the Company's periodic filings with the Securities and Exchange Commission, including the "Risk Factors" section of Mattel's Annual Report on Form 10-K for the fiscal year ended December 31, 2015 and Mattel's Quarterly Reports on Form 10-Q for fiscal year 2016, as well as in Mattel's other public statements. Mattel does not update forward-looking statements and expressly disclaims any obligation to do so.

Non-GAAP Financial Measures

To supplement our financial results presented in accordance with generally accepted accounting principles in the United States ("GAAP"), Mattel presents certain non-GAAP financial measures within the meaning of Regulation G promulgated by the Securities and Exchange Commission. The non-GAAP financial measures that Mattel uses in this earnings release includes gross sales, adjusted other selling and administrative expenses, adjusted operating income, adjusted earnings per share and constant currency. Mattel uses these metrics to analyze its continuing operations and to monitor, assess and identify meaningful trends in its operating and financial performance, and each is discussed in detail below. These measures are not, and should not be viewed as, substitutes for GAAP financial measures. Reconciliations of the non-GAAP financial measures to the most directly comparable GAAP financial measures are attached to this earnings release as exhibits and to our earnings slide presentation as an appendix.

This earnings release and our earnings slide presentation are available on Mattel's Investor Relations website, http://investor.shareholder.com/mattel (http://investor.shareholder.com/mattel), under the subheading "Financial Information – Earnings Releases."

Gross sales

Gross sales represent sales to customers, excluding the impact of sales adjustments. Net sales, as reported, include the impact of sales adjustments, such as trade discounts and other allowances. Mattel presents changes in gross sales as a metric for comparing its aggregate, brand and geographic results to highlight significant trends in Mattel's business. Changes in gross sales are discussed because, while Mattel records the details of such sales adjustments in its financial accounting systems at the time of sale, such sales adjustments are generally not associated with brands and individual products, making net sales less meaningful.

Adjusted other selling and administrative expenses

Adjusted other selling and administrative expenses represents Mattel's reported other selling and administrative expenses, adjusted to exclude the impact of expenses associated with the acquisition and integration of an acquired business and restructuring and restructuring-related expenses. Adjusted other selling and administrative expenses is presented to provide additional perspective on underlying trends in Mattel's core other selling and administrative expenses.

Adjusted operating income

Adjusted operating income represents Mattel's reported operating income, adjusted to exclude expenses associated with the acquisition and integration of an acquired business and the impact of restructuring and restructuring-related expenses. Adjusted operating income is presented to provide additional perspective on underlying trends in Mattel's core operating results.

Adjusted earnings per share

Adjusted earnings per share represents Mattel's reported diluted earnings per common share, adjusted to exclude expenses associated with the acquisition and integration of an acquired business, the impact of restructuring and restructuring-related expenses, sale of non-core assets, and currency devaluations. The aggregate tax effect of the adjustments is calculated by tax effecting the adjustments by the current effective tax rate, and dividing by the reported weighted average number of common and potential common shares. Adjusted earnings per share is presented to provide additional perspective on underlying trends in Mattel's core earnings. Adjusted earnings per share is a performance measure and should not be used as a measure of liquidity.

Constant currency

Percentage changes in results expressed in constant currency are presented excluding the impact from changes in currency exchange rates. To present this information, Mattel calculates constant currency information by translating current period and prior period results for entities reporting in currencies other than the US dollar using consistent exchange rates. The consistent exchange rates are determined by Mattel at the beginning of each year and are applied consistently during the year. They are generally different from the actual exchange rates in effect during the current or prior period due to volatility in actual foreign exchange rates. Mattel established the exchange rates that it uses for these constant currency calculations years ago. It considers whether any changes to these rates are appropriate at the beginning of each year but, generally, has held them unchanged. The difference between the current period and prior period results using the consistent exchange rates reflects the changes in the underlying performance results, excluding the impact from changes in currency exchange rates. Mattel analyzes constant currency results to provide additional perspective on changes in underlying trends in Mattel's operating performance.

About Mattel

Mattel is a creations company that inspires the wonder of childhood. Our mission is to be the recognized leader in play, learning and development worldwide. Mattel's portfolio of global consumer brands includes American Girl®, Barbie®, Fisher-Price®, Hot Wheels®, Monster High® and Thomas & Friends®, among many others. Mattel also creates a wealth of lines and products made in collaboration with leading entertainment and technology companies. With a global workforce of approximately 31,000 people, Mattel operates in 40 countries and territories and sells products in more than 150 nations. Visit us online at www.mattel.com (http://www.mattel.com/).

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[1] Please refer to Non-GAAP Financial Measures for a glossary of non-GAAP financial measures used herein, including gross sales, adjusted other selling and administrative expenses, adjusted operating income, adjusted earnings per share and constant currency.
[2] The NPD Group/Retail Tracking Service/US/Q4 2016/Total Toys/Dollars.

MATTEL, INC. AND SUBSIDIARIES

CONSOLIDATED STATEMENTS OF OPERATIONS (Unaudited)

	For the Three Months Ended December 31,						For the Year Ended December 31,				
					Yr / Yr % Change as Reported	Yr / Yr % Change In Constant Currency					Yr / Yr % Change as Reported
(In millions, except per share and percentage information)	2016 $ Amt	% Net Sales	2015 $ Amt	% Net Sales			2016 $ Amt	% Net Sales	2015 $ Amt	% Net Sales	
Net Sales	$ 1,834.4		$ 1,999.7		-8%	-6%	$ 5,456.7		$ 5,702.6		-4%
Cost of sales	973.0	53.0%	996.2	49.8%	-2%		2,902.3	53.2%	2,896.2	50.8%	0%
Gross Profit	861.4	47.0%	1,003.5	50.2%	-14%	-9%	2,554.4	46.8%	2,806.4	49.2%	-9%
Advertising and promotion expenses	250.3	13.6%	297.4	14.9%	-16%		634.9	11.6%	717.9	12.6%	-12%
Other selling and administrative expenses	348.5	19.0%	412.0	20.6%	-15%		1,400.3	25.7%	1,547.6	27.1%	-10%
Operating Income	262.6	14.3%	294.1	14.7%	-11%	7%	519.2	9.5%	540.9	9.5%	-4%
Interest expense	25.0	1.4%	22.8	1.1%	10%		95.1	1.7%	85.3	1.5%	12%
Interest (income)	(1.6)	-0.1%	(1.5)	-0.1%	8%		(9.1)	-0.2%	(7.2)	-0.1%	26%
Other non-operating expense (income), net	0.3		2.0				23.5		(1.1)		
Income Before Income Taxes	238.9	13.0%	270.8	13.5%	-12%	6%	409.7	7.5%	463.9	8.1%	-12%
Provision for income taxes	65.1		55.6				91.7		94.5		
Net Income	$ 173.8	9.5%	$ 215.2	10.8%	-19%		$ 318.0	5.8%	$ 369.4	6.5%	-14%
Net Income Per Common Share - Basic	$ 0.51		$ 0.63				$ 0.93		$ 1.08		
Weighted average number of common shares	342.7		339.8				341.5		339.2		

Net Income Per Common Share - Diluted	$ 0.50	$ 0.63	$ 0.92	$ 1.08
Weighted average number of common and potential common shares	345.0	340.4	344.2	339.7

MATTEL, INC. AND SUBSIDIARIES **EXHIBIT II**

CONDENSED CONSOLIDATED BALANCE SHEETS

	December 31,	
	2016	**2015 (b)(c)**
(In millions)	**(Unaudited)**	
Assets		
Cash and equivalents	$ 869.5	$ 892.8
Accounts receivable, net	1,115.2	1,145.1
Inventories	613.8	587.5
Prepaid expenses and other current assets	341.5	375.7
Total current assets	2,940.0	3,001.1
Property, plant, and equipment, net	771.4	741.1
Other noncurrent assets	2,779.8	2,792.9
Total Assets	$ 6,491.2	$ 6,535.1
Liabilities and Stockholders' Equity		
Short-term borrowings	$ 192.2	$ 16.9
Current portion of long-term debt	-	300.0
Accounts payable and accrued liabilities	1,293.7	1,309.8
Income taxes payable	19.7	18.8
Total current liabilities	1,505.6	1,645.5
Long-term debt	2,134.3	1,784.7
Other noncurrent liabilities	446.1	471.7
Stockholders' equity	2,405.2	2,633.2
Total Liabilities and Stockholders' Equity	$ 6,491.2	$ 6,535.1

SUPPLEMENTAL BALANCE SHEET AND CASH FLOW DATA (Unaudited)

	December 31,	
(In millions, except days and percentage information)	2016	2015 (b)
Key Balance Sheet Data:		
Accounts receivable, net days of sales outstanding (DSO)	55	52
Total debt outstanding	$ 2,326.5	$ 2,101.6
Total debt-to-total capital ratio	49.2%	44.4%

	Year Ended December 31,	
(In millions)	2016 (a)	2015
Condensed Cash Flow Data:		
Cash flows from operating activities	$ 590	$ 735
Cash flows (used for) investing activities	(307)	(283)
Cash flows (used for) financing activities and other	(306)	(531)
Decrease in cash and equivalents	$ (23)	$ (79)

(a) Amounts shown are preliminary estimates. Actual amounts will be reported in Mattel's Annual Report on Form 10-K for the year ended December 31, 2016.

(b) Other noncurrent assets and long-term debt have been retrospectively restated to reflect the adoption of Accounting Standards Update (ASU) 2015-03, *Simplifying the Presentation of Debt Issuance Costs*.

(c) ASU 2015-17, *Balance Sheet Classification of Deferred Taxes*, was retrospectively adopted in the quarter ended March 31, 2016. As of December 31, 2015, prepaid expenses and other current assets decreased by $195.8 million, other noncurrent assets increased by $193.6 million, and other noncurrent liabilities decreased by $2.2 million.

MATTEL, INC. AND SUBSIDIARIES

EXHIBIT III

WORLDWIDE GROSS SALES INFORMATION (Unaudited)

RECONCILIATION OF GAAP AND NON-GAAP FINANCIAL MEASURES

	For the Three Months Ended December 31,		For the Year Ended December 31,	
(In millions, except percentage information)	2016	2015	2016	2015

			% Change as Reported	% Change in Constant Currency				% Change as Reported	% Change in Constant Currency	
Worldwide Gross Sales by Brand:										
Mattel Girls & Boys Brands	$ 1,051.4	$ 1,136.6	-7	% -3	%	$ 3,194.1	$ 3,464.2	-8	% -5	%
Fisher-Price Brands	607.7	626.2	-3	2		1,888.1	1,852.2	2	6	
American Girl Brands	283.9	271.8	4	5		570.8	572.0	0	0	
Construction and Arts & Crafts Brands	124.8	130.2	-4	1		377.6	351.7	7	15	
Other	15.7	20.1				43.1	43.5			
Gross Sales	$ 2,083.5	$ 2,184.9	-5	% -1	%	$ 6,073.7	$ 6,283.6	-3	% 0	%
Worldwide Gross Sales - Mattel Girls & Boys Brands:										
Barbie	$ 320.5	$ 327.6	-2	% 1	%	$ 971.8	$ 905.9	7	% 9	%
Other Girls	157.2	268.6	-41	-35		461.7	954.4	-52	-47	
Wheels	306.1	271.8	13	18		885.1	831.3	6	11	
Entertainment	267.6	268.6	0	2		875.5	772.6	13	16	
Gross Sales	$ 1,051.4	$ 1,136.6	-7	% -3	%	$ 3,194.1	$ 3,464.2	-8	% -5	%
Reconciliation of Non-GAAP to GAAP Financial Measure:										
Gross Sales	$ 2,083.5	$ 2,184.9				$ 6,073.7	$ 6,283.6			
Sales Adjustments[1]	(249.1)	(185.2)				(617.0)	(581.0)			
Net Sales	$ 1,834.4	$ 1,999.7	-8	% -6	%	$ 5,456.7	$ 5,702.6	-4	% -2	%

[1] Sales adjustments are not allocated to individual products. As such, net sales are only presented on a consolidated basis and not on a brand level.

MATTEL, INC. AND SUBSIDIARIES **EXHIBIT IV**

GROSS SALES BY REGION (Unaudited)

RECONCILIATION OF GAAP AND NON-GAAP FINANCIAL MEASURES

	For the Three Months Ended December 31,		For the Year Ended December 31,	
(In millions, except percentage information)	**2016**	**2015**	**2016**	**2015**

			% Change as Reported	% Change in Constant Currency				% Change as Reported	% Change in Constant Currency	
North American Region Gross Sales[1]										
Gross Sales	$ 1,250.0	$ 1,313.5	-5	% -5	%	$ 3,626.1	$ 3,680.1	-1	% -1	%
Sales Adjustments	(89.4)	(59.1)				(224.2)	(219.0)			
Net Sales	$ 1,160.6	$ 1,254.4	-7	% -7	%	$ 3,401.9	$ 3,461.1	-2	% -1	%
International Region Gross Sales										
Europe										
Gross Sales	$ 426.4	$ 460.4	-7	% 1	%	$ 1,293.3	$ 1,388.8	-7	% 0	%
Sales Adjustments	(94.4)	(76.9)				(230.4)	(215.6)			
Net Sales	$ 332.0	$ 383.5	-13	% -6	%	$ 1,062.9	$ 1,173.2	-9	% -3	%
Latin America										
Gross Sales	$ 233.2	$ 244.6	-5	% 7	%	$ 636.5	$ 711.0	-10	% 0	%
Sales Adjustments	(35.0)	(22.7)				(84.9)	(81.4)			
Net Sales	$ 198.2	$ 221.9	-11	% -1	%	$ 551.6	$ 629.6	-12	% -3	%
Asia Pacific										
Gross Sales	$ 173.9	$ 166.4	5	% 6	%	$ 517.8	$ 503.7	3	% 5	%
Sales Adjustments	(30.3)	(26.5)				(77.5)	(65.0)			
Net Sales	$ 143.6	$ 139.9	3	% 5	%	$ 440.3	$ 438.7	0	% 3	%
Total International Region										
Gross Sales	$ 833.5	$ 871.4	-4	% 4	%	$ 2,447.6	$ 2,603.5	-6	% 1	%
Sales Adjustments	(159.7)	(126.1)				(392.8)	(362.0)			
Net Sales	$ 673.8	$ 745.3	-10	% -2	%	$ 2,054.8	$ 2,241.5	-8	% -2	%

[1] Consists of U.S., Canada, and American Girl.

MATTEL, INC. AND SUBSIDIARIES

EXHIBIT V

SUPPLEMENTAL FINANCIAL INFORMATION (Unaudited)

RECONCILIATION OF GAAP AND NON-GAAP FINANCIAL MEASURES

	For the Three Months Ended December 31,		For the Year Ended December 31,	
(In millions, except per share and percentage information)	**2016**	**2015**	**2016**	**2015**
Other Selling and Administrative Expenses				
Other Selling and Administrative Expenses, As Reported	$ 348.5	$ 412.0	$ 1,400.3	$ 1,547.6
% of Net Sales	*19.0%*	*20.6%*	*25.7%*	*27.1%*
Adjustments:				
Integration & Acquisition Costs (1)	(0.3)	(1.3)	(1.7)	(14.9)
Severance and Restructuring Expenses	(6.3)	(10.9)	(39.9)	(67.8)
Other Selling and Administrative Expenses, As Adjusted	$ 341.9	$ 399.8	$ 1,358.7	$ 1,464.9
% of Net Sales	*18.6%*	*20.0%*	*24.9%*	*25.7%*
Operating Income				
Operating Income, As Reported	$ 262.6	$ 294.1	$ 519.2	$ 540.9
Adjustments:				
Integration & Acquisition Costs (1)	0.3	1.3	1.7	14.9
Severance and Restructuring Expenses	6.3	10.9	39.9	67.8
Operating Income, As Adjusted	$ 269.2	$ 306.3	$ 560.8	$ 623.6
Earnings Per Share				
Net Income Per Common Share, As Reported	$ 0.50	$ 0.63	$ 0.92	$ 1.08
Adjustments:				
Integration & Acquisition Costs (1)	-	-	-	0.04
Severance and Restructuring Expenses	0.02	0.03	0.12	0.20
Sale of Assets	-	-	(0.01)	-
Venezuela Currency Devaluation Loss	-	-	0.08	-
Tax Effect of Adjustments (2)	-	(0.01)	(0.05)	(0.05)
Net Income Per Common Share, As Adjusted	$ 0.52	$ 0.65	$ 1.06	$ 1.27

(1) Includes Integration & Acquisition Costs for Fuhu and Sproutling in 2016 and MEGA Brands in 2015.

(2) The aggregate tax effect of the adjustments is calculated by tax effecting the adjustments by the current effective tax rate, and dividing by the reported weighted average number of common and potential common shares.