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RESEARCH ON THE COMBINATION OF SUSTAINABILITY AND AFFECTIVE ENGINEERING IN THE EXHIBITION DESIGN MANAGEMENT

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ABSTRACT

This research targets to realize sustainability and meet the visitors' mental needs by carrying out environmental strategies and analyzing visitors' requirements. The findings are on three aspects. To make exhibitions sustainable, the life period of activities and facilities should be planned under the sustainable evaluation models. Reduce material and energy usage is the key factor. To meet visitors affective needs, materials and designs should be linked with human feelings. To combine the two theories, sustainable materials should be compared to human feelings, and materials that appeal to human should be verified by sustainable principles. This research provides detailed cases, practical ways and suggestions for contemporary exhibition on combining sustainability and affective engineering.

Keywords: sustainable design, LCA, LiDS, Kansei Engineering, exhibition design, expo

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INTRODUCTION

With the rapid development of exhibition industry in recent years, the prosperity of exhibition is becoming a vital indicator for the cultural development level of a country. With different purposes, the exhibition scales may vary. Big exhibitions can be Expos and national museums, and small ones can be local exhibitions in small cities or those relate to specific topics. At the same time, the construction and development of museums and galleries are prospered during the decades.

Meanwhile, with the progress of industrialization and urbanization, there comes a lot of environmental problems. For instance, global warming that results from greenhouse gas emissions, deforestation caused by overdeveloping woods, soil acidification because of the inappropriate use of chemical fertilizer, the air and water pollution due to the discharging of industrial exhaust and effluent, etc.[1] It is the conflict between the environmental deterioration and the pursuit of high-qualified living in human society that various ecological and ergonomic ideas are proposed. Especially the notion of 'affective engineering' in the past few decades, which is focused on the mental need of human beings, and aimed to find correlations between objects and human feeling, has been widely spread and applied into product design practice.

This trend is also revealed in the exhibition industry, since two factors in the exhibition had raise visitors' concern: one is the sustainability or sustainable development of the exhibition and the exhibiting environment; another is the physical and mental comfort that the indoor services and interactive activities can provide to the audience, which is related to the discipline of ergonomics and affective engineering.

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The motive to introduce the sustainable rules and affective engineering principles is, even exhibitions gained more popularity, there are still unreasonable phenomena in the exhibition design and management. For example, the transport of longer distance and less efficiency, the waste of display tools and construction materials, the unsustainable material selection and manufacture of tools and furniture, the confusion and disorder in the ways of display and the arrangement of exhibit spaces, and many visitors in the exhibition has not devoted themselves thoroughly into activities.

In this paper, the application of sustainable rules and affective engineering principles will be elaborately described and verified in exhibition cases. Precisely, sustainable rules may be applied for material selection and processing for displaying tools and furniture, the energy utilization during activities, and the disposal after the use of facilities. And affective engineering, although it is a new area and there is very few direct use in exhibitions, it can be assumed as a tool for planning the layout, and in the product designs that related to exhibitions.

In the research, the question on 'how to combine sustainability and affective engineering in exhibition design management' will be answered. The intersection will be elaborated among principles of display design, sustainability and affective engineering in the exhibition industry. So, in the context, there will be an illustrated analysis on literature data of sustainability rules and strategies, sustainable evaluation criteria, affective engineering systems and exhibition cases. Then, solutions and useful advice will be given for exhibition design and management.

Therefore, this research aimed to find feasible ways to apply and combine the sustainability and affective engineering in today's exhibition industry. The research objectives are, for one thing, to make exhibitions comply with the criteria of environmental protection, then to be more environmental friendly in the manufacturing and utilizing periods of displaying props and furniture; for another, to meet the physical and mental needs of the audience, and to provide more humanized services during the exhibition.

The introduction of sustainable design

The idea of 'Sustainable Development' was firstly proposed in 1972 at the 'United Nation Conference on Human Environment'. In 1987, 'Our Common Future' was published, which gives an accurate explanation of sustainable development as "meeting the needs of the present without compromising the ability of future generations to meet their own needs".[2]

Afterwards, various principles were published, which aimed at sustainable development and environment protection, such as the Kyoto Protocol in 2005 that focused on the discharge of green gases.

In design area, the sustainable development also has the particular meaning. According to Abeyasekera K., It refers to focus on fulfilling the balance of social, economic and ecological sustainability.[3]

Later on, the sustainability tends to be a new area to ergonomics. This combined idea is aimed at realizing the sustainable design from a holistic point of view. As to the requirement of this combination, Martin K. mentioned that the ergonomics need to help the mankind live harmoniously with the planet, rather than merely meeting their physical needs.[4] Although the study may lack a clear classification and extensive acceptance as it links different disciplines and industries, there are some benefits. For example, the working efficiency and living standards could be significantly improved, because there is a consideration on both of the human factors and the ecological protection.

Sustainable design strategies for exhibitions

In general, there are two rules for sustainable design. One is to minimize resource consumption, the other is to reduce pollution.[5] Abeyasekera puts forward that, in order to minimize resource consumption, the use of renewable source is required, and the consumption of non-renewable ones as well as materials that

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in shortest supply should be minimized. Then, the recycling of materials need to be maximized. To reduce pollution, the inappropriate and irresponsible use of resource should be avoided, and heavy metals and toxic chemicals need to be strictly limited.

An introduction of sustainable design strategies is also given in this book, which targets to apply sustainable principles in the contemporary exhibition design. The strategies include consumer desire analysis, cradle-to-grave analysis, dematerialization, design for dis-assembly, etc.

In short, the 'consumer desire analysis' means, design should be used as a tool for delivering the ideas of an exhibition.[6] For example, the mainstream of society regard exhibitions as very modern, and the performance may be sacrificed to make an exhibition sustainable. So, consumers wish exhibitions to be 'well-performed and also sustainable'. There is a misunderstanding that 'exhibitions can only be either environmental friendly or performed aesthetically', but actually two aspects can be achieved at the same time.

The 'cradle-to-grave analysis', also called 'life cycle assessment', refers to the management of a product during all aspects of its life. This period is from the material specification to the utilization, disposal and the recycle of products. For instance, hemp, Poly Vinyl Chloride (PVC) and glass might be selected when making the top roof in public spaces. Among these materials, Hemp is natural and biodegradable, but it is not weather-proof and can be easily corroded. PVC and glass are difficult to biodegrade, but PVC is slightly toxic and is harmful when used for long time, while the glass is non-poisonous. So, from the comparison, the glass roof may be the best choice. **(Figure 1.)**

(figure 1. the Glass roof is long-lasting and non-toxic, geograph.org)

Dematerialization refers to minimize material consumption. According to Pralea J. et al, there are three approaches: make design and process simpler; make products lighter or smaller; recycle the waste of materials.[7] The benefits of dematerialization are, simpler manufacturing of products can save more time and resource; lessening weight and volume of items can improve the transportation efficiency, and recycling material waste will reduce the use of virgin materials. However, making synthetic materials is not so sustainable even it is an approach of dematerialization, because it requires more energy to process, and resins and glues are harmful to human health.

'Eco-assembly' requires products to be fitted by single parts then can be reused individually for other purposes.[8] It is benefit for reducing waste and landfill. By eco-assembling, the proportion of reused material can be greatly increased. In exhibitions, this method can be applied when displaying props are used for many times and occasions.

On waste management, three strategies are mentioned: control the generation of waste; reduce the pollution and hazardous waste by specifying biodegradable materials; recycle the waste.[9] Precisely, as for specifying sustainable materials, criteria may vary, such as availability, recyclability, energy consumed, cost and performance. As for waste recycling, it is vital to select natural, biodegradable or long-lasting reusable

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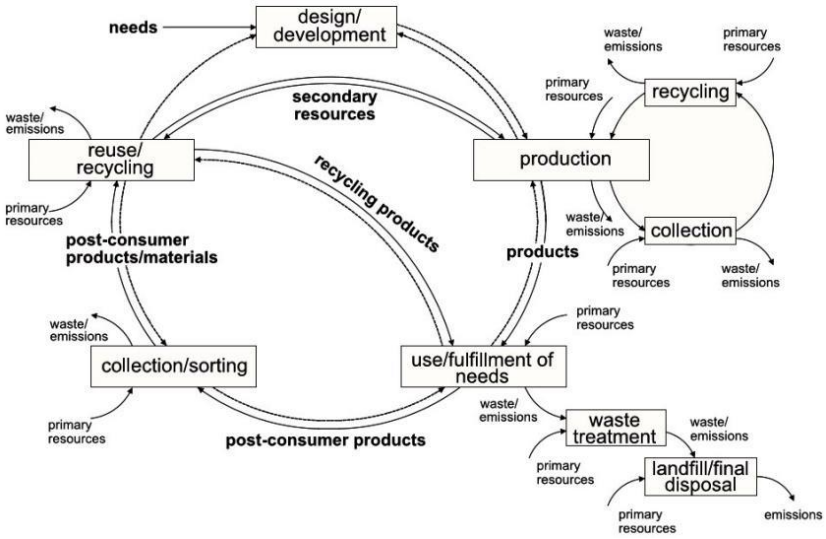
materials, and increase the reuse proportion manufacturing and processing.

Sustainable evaluation models

Apart from sustainable strategies, series of evaluation models and environmental accreditation is also required for sustainable development.

In specific, evaluation models that generally adopted are the 'Life Cycle Assessment', 'Life Time Design Strategies Wheel', 'Reduce, Reuse, Recycle', etc.

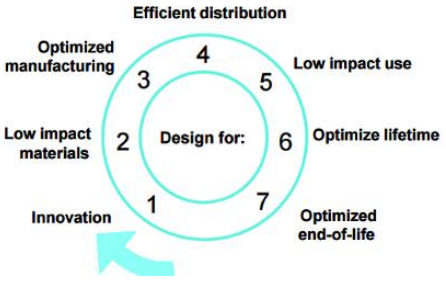
The 'Life Cycle Assessment' (LCA) is a comprehensive system including multiple tools. According to ISO (2006), the LCA is also called the 'Cradle-to-grave' principle. In **figure 2.**[10], what the life circle of a general product might be is illustrated.



(figure 2. the Life Circle of a general product, Rebitzer G.)

Accordingly, the evaluation starts from consumer needs (physical or psychological), then on to product design and manufacture. After the usage of products it is the collection and reuse period, then the recycling of materials and the management of waste. LCA can help managers to avoid a lack of foresight on environment aspects. To follow the rules, the US Environmental Protection Agency requires that, a checklist should be made for monitoring the resource usage and relative influences on environment, the harmful release should be carefully limited, and results should be analyzed in order to make a well-considered instruction.[11]

Besides, the Life Time Design Strategies (LiDS) Wheel could also be a useful assessment tool. It divides the sustainable design and development process into 7 stages **(figure 3.)** which follows the order of a product's life period.



(figure 3. LiDS Wheel, sustainableminds.com.)

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'Innovation' is to rethink or generate new concept for the development of products.[12] It means that, in exhibitions more benefit should be provided to meet visitors' needs. For instance, facilities or services such as displaying tools should be user-sharing and upgraded easily.

'Low impact materials' requires designers to use non-hazardous, renewable, and thoroughly tested materials, and increase the usage proportion of waste byproducts.[13] There are new materials that with low impact. For example, Oxman N. introduced a theory called 'design by nature', along with the new application of chitin. Chitin can be extracted from organism from shrimps, crabs or butterflies, which is natural and sustainable.[14] It is not a new material but Oxman provides a new approach of utilization. The synthetic fiber that made with chitin is similar to plastic, but can adjust functionality by perceiving the light and heat. When there is more light in the surrounding, it can be softer and more transparent. Once after used, during degrading, chitin can capture carbon dioxide and convert the carbon into sugar.[15] Therefore, chitin might be a substitute for plastics because of its similar texture and eco-friendly disposal. If developed well, this natural material can be applied extensively, because shells of insects can be cultivated easily.

(figure 4. Chitin from shells of crabs. Oxman N.)

'Optimized manufacturing' means, during the processing, hazards should be avoided, and the material usage, energy usage and waste should be minimized.[16] Also, the weight and volume of the product and package should be reduced, and the package should be reusable or recyclable. Moreover, factories are supposed to use cleaner energy, and increase the energy efficiency.

'Efficient distribution' refers to design for dis-assembly, and choose more efficient transporting tools to carry facilities.[17] To minimize the transportation, facilities could be produced and assembled locally. 'Low impact use' is to control the waste generation and emission.[18] For the long-term exhibition, the site should be built for durability and designed for maintenance. Based on LiDS, the initial lifetime is the utilizing time for an item considering the overall durability. This can be prolonged when it designed for maintenance, easy repair and second life. The other way is to make facility components with standard size and shape, so that each part can be replaced easily. Besides, during the activities, advice should be given to users on how to take care of facilities.

The management of 'End-of-life' requires for 'design for dis-assembly'.[19] On this basis, facilities or components should be made for directly reuse, downcycling reuse or recycle. After facility manufacturing and using, the waste should be safely disposed, such as biodegraded.

In addition, the 'Reduce, Reuse, Recycle' (3Rs) is also widely accepted. In exhibitions it means, during the facility making and activity operating, the material use, energy consumption and waste should be reduced. For making displaying tools, reused materials are better than virgin ones, and components of facilities should be designed for dis-assembly and reuse. Moreover, during manufacturing and displaying, it is encouraged to use renewable energy sources. 'Recycle' means that displaying tools can be made for second use and multiple use. Also, it is sustainable that one type of energy could be converted into another and stored for future use.

Not only measuring models, but the environmental accreditation can evaluate designs and materials as

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well. The most accepted ones are the ISO series and the Green Mark Award Scheme.

International Standards Organization (ISO) developed several principles for environmental evaluation and management. In particular, the ISO14001 can be applied for verifying whether a company had set environmental policies, and whether the policies are well executed regarding to the key issues.[20] So, companies can set the sustainable policies to monitor their working process, and follow the standards to improve their eco-friendly levels.

The Green Mark Award Scheme means that, if more schemes awarded as 'Green Marks' in a company, a high level of implementation on ecological protection policies can be reflected, or a basic sustainable management system is adopted. [21]

In exhibitions, managers can compare the exhibiting tools, services and activities to ISO policies and Green Mark criteria to improve their sustainable levels.

Although there are diverse evaluation methods for sustainability, they all try to achieve a quantification more objectively of impacts on the environment.

The introduction of affective engineering

'Affective Engineering' is a new branch of ergonomics. It focused on developing products that caring about the users' psychological feelings, and meeting their needs in mind.[22]

Affective engineering is introduced around 1970 in Japan that primarily called Kansei engineering. It is a customer-oriented product development method that targets to realize the product's best fit to user needs. According to Nagamachi, by adopting this theory, people's feelings on items can be analyzed by using statistical methods, and the result data can be transferred into design domain.[23]

The reason to introduce the affective engineering to exhibition is, exhibitions need to communicate with audiences. If audiences can enjoy a more humanized and comfortable activities, the exhibition can built an intimacy between them and the exhibits.

To adopt the technology in exhibitions, four points should be considered: how to inquire the visitor's feeling about a material or furniture; how to link the large number of designs or materials with the visitor's feeling; how to convert affective engineering theories into practical technologies that more related to the exhibition design; and, how to keep designs updated with the constantly changing needs of audiences.

Affective Engineering Systems and Applications

In exhibition design and management, the domain affective engineering system that could be applied are Kansei Engineering System (KES), Human Living System (HULIS), and Virtual Kansei Engineering (ViVA).

According to Nagamachi, the principle of KES is to match images of design elements with people's emotional needs. This system was firstly adopted in the car industry when Mazda developed a sports car 'Miyata'. When the image is put into the system, related emotional feelings will be analyzed.[24] So, it is easy to reach the affective words if a database is built to link with different materials, colors and textures. It was followed by the proposal of 'Color Planning System(CPS)', which can specify different colors by affective words.[25] In this research, to solve the four main problems in exhibitions, the KES can be applied as follows.

To explore the user's feeling about a material or furniture, a database of feeling words should be collected, and the most frequent ones should be selected. To link various designs and materials with the words of feeling, a questionnaire survey could be made to find the relations between words of feelings and materials. To apply affective engineering theories to practical technologies in exhibitions, the use of KES network model or computerized calculating system should be authorized. To keep the resource data in line with the needs of audiences, the database of designs as well as affective words should be updated every few years.

Furthermore, Nagamachi developed HULIS as a branch of KES. This system is similar to KES, and it

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translates affective words and requirements into images.[26] In HULIS, complicated designs and images that stored in the database can be matched with words of feeling. Therefore it is assumed that, in exhibitions, complicated requirements on displaying facilities and lounge furniture can be inputted and calculated, then the best choice of designs from user's perspective can be selected.

So, if KES is combined with HULIS in exhibitions, the evaluation on facilities and the analysis on visitors' feelings can be conducted in the same time.

Besides, ViVA is a virtual affective engineering system for home design. When the family data (lifestyle data) is inputted, ViVA could make calculations and show lots of matched examples of room design. Hence in exhibitions, this system might be applicable for the space and displaying arrangements, although it has not been achieved.

Methodology

This study mainly led to a qualitative research which targets to find methods of combining domain theories of sustainability and affective engineering. Then it was to investigate reasons and motives of human behaviors, attitudes and opinions.

In the literature study and survey data collection, a descriptive research was given to report the development of theories, and to discover answers for the research question. For finding correlations and making comparisons, an analytical research was conducted, including the critical evaluation on material selection and designs.

In particular, applied research methods are as follows.

Literature study

The purpose of literature study is to identify the context and progress of the research field, so that the author could have a general understanding of previous studies.[27]

For collecting the topic-related data, firstly it was to identify keywords. In this study, keywords were extracted from the title 'combining sustainability and ergonomics in the exhibition design management' as: exhibition design, sustainable exhibition, sustainable design, sustainability and ergonomics, ecological ergonomics, affective engineering...etc.

Then it was to find the literature. The online source were obtained from Google Scholar, the website of the university library, and official websites of academic journals. The offline source were from published books and journal articles, and industry reports.

The next step was to take notes and make comparison on different ideas, and describe or summarize applicable ones.[28] Afterwards, relevant ideas were critically evaluated with examples, and hypothesis of problem-solving was given.

Case study

The purpose of a case study is to investigate specific issues in depth under limitations of a particular situation. It can be categorized as explanatory, descriptive and exploratory studies.[29]

In this paper, for analyzing reasons and motives of specific exhibiting measures, the explanatory research was adopted; for describing different strategies between cases and their outcomes, the descriptive research was conducted; for speculating the impact on society based on the policies that executed in the cases, the exploratory research was applied.

In precise, firstly, there was a critical review on two cases: Shanghai Expo 2010 which is about sustainable building and living, and 'Sensual Dynamics Project' which is about affective products and services.

Then, it was to find useful and feasible methods on material selection and energy resource management, as well as find the correlations of mental needs with different materials.

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Afterwards, the selected methods were categorized in terms of: for sustainable design and management; for meeting affective needs of audiences; and for combining the sustainability and affective engineering in the exhibition.

Surveys

In this research, survey method was adopted to question individuals about their preferences and attitudes[30] of different materials, exhibiting ways, facilities, and services. Then, responses were collected, described and clearly analyzed.

The purpose of the survey is to improve the level of visiting satisfaction, by accessing problems discovered by audience, and the advice given from their point of view.

The type of survey is mail survey online. To be specific, website links of the questionnaire were given via e-mail or posted on social media (such as Facebook or Wechat). There were seven questions included, respectively about the participants' frequency of exhibitions visiting, the displaying ways they like, the materials for exhibiting tools and lounge furniture they prefer, their emotional feelings when seeing certain materials, the services they mostly concerned about, and the problems they find or issues they are not satisfied with.

The reasons of delivering questionnaire are, it can collect large amount of information in a relatively short time, and to make the data collection period cheaper.[31]

In precise, website links were sent to roughly 100 students (at random) who studies in the UK and China. Some of them are classmates of the author and are design-related students, and others can be friends of friends who studies or works in different disciplines or industries. The reason is, exhibitions appeals to be more attractive to art-related or design-related students, however, they are only a tiny group of general public. In fact, a successful exhibition need to attract visitors across various working industries.

To collect feedback data, the online survey software 'SurveyMonkey' was applied. Once the survey had finished, the results were collected, categorized and made into graphs at the same time. After that, the measurement and data analysis were conducted.

Results and discussions

By analyzing literature resources and case reports, findings and discussions can be given.

Case study 1: Shanghai Expo 2010

As a representative of large-scale exhibitions, the Expo conveys concepts that synchronized with characteristics of eras and needs of people. It is because the Expo 2010 is recognized as one of the largest projects in developing countries, this case can be an important guidance for managing large-scale exhibitions.

The topic of the Expo 2010 is 'better city, better life'.[32] Under the guidance of the theme, there comes lots of sub streams, such as 'Innovation of Science and Technology', 'Rural-Urban Interaction', and 'Economic-Social-Environmental Prosperity'. To realize the goal in activities rather than merely advocate the idea, various policies are made for achieving sustainable development in the practical level.

In the following paragraphs, analysis will be taken respectively on sustainable policies of Expo 2010, reasons why they were made, difficulties in the implementation of rules, the tackling measures, and outcomes and lessons learned.

Sustainable policies of Expo 2010

The first step of policies making is to determine the main goal and guidelines. In regards to the sustainable development, according to Qian S., aims of Expo 2010 are to limit the resource and energy consumption, minimize the burden on environment, and provide audiences with a more comfortable place.[33]

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In order to fulfill requirements, conceptual guidelines are required. Qian S. indicated three steps in the inception phase. Firstly, a program management team was established to guide and monitor the implementation of all projects. Then, governmental investment was mostly allocated to three factors: conservation of energy, protection of ecosystem, and the guarantee of human health.[34] This arrangement contributed greatly for the development of sustainability as well as human physical and psychological health.

Next is to execute concepts into design practice. In this step, various sustainable issues are included, which focused on the land use, energy and water efficiency, ecological loading reduction, materials reuse, etc. For example, the planning of land use can be revealed in the arrangement of grasslands and parks that surround pavilions. To improve energy efficiency, according to the Bureau of Shanghai World Expo Coordination, designers are required to use clean or renewable energies, and reduce the waste water. Besides, strategies are also conducted by the coordination department on the release of environmental burden, such as minimize the generation of effluents, greenhouse gases and solid waste.[35] In this phase, although participants can remain different measures regarding their own countries and regulations, some general policies still regulated their conduct throughout each of projects.

In the construction phase, strategies were given for the pavilion making and operating. The strategies are aimed at reducing the energy and material use, and enhancing efficiency. Finally, the existing structure was reused, the proportion of recycled displaying tools and materials was increased, and the waste was disposed safely.

Barriers and difficulties in the policy implementation

Even sufficient consideration was taken in the policy making, there are many obstacles when applying strategies in practice.

An obvious difficulty is the lack of funding to ensure all projects to be qualified.[36] This can be seen in some self-built pavilions that, managers intended to use more cleaner energy (e.g. geothermal power) to support the exhibition, but they are failed due to the limited capital.[37] It is assumed that the lack of funding may result in other problems such as technical difficulties. Besides, Expo exhibitions are mostly temporary and will be finally dismantled. Therefore sponsors may not willing to invest largely on the clean energy use.

The second barrier is, participants have little understanding of local regulations.[38] There are distinctive conditions among different areas, especially conditions that regarding to local environment or sustainable constructions. It is because of the few knowledge of local conditions (such as weather and the supply of water and electricity) that some activities have negative effects on local ecology.

This barrier also comes from different understandings on ‘sustainability’ or ‘scarce resource’ of participants form different areas.[39] For instance, in some place (e.g.Brazil) water-powered electricity is utilized broadly, and the large consumption of water is due to the abundant water resource. For this reason, the local government may not aware that saving water can be part of sustainable development in other areas. Nonetheless, if such an exhibition is held in other areas, especially areas where established water-saving policies due to resource scarcity, there will be a conflict with local regulations. In brief, it is the inquiries and consultation that takes relatively long period considering the interest conflicts among exhibition managers, sponsors and local governments, which results in the lack of efficiency and the delay of program approval.

Solutions and examples

In view of difficulties and problems above, the Expo 2010 launched series of solutions.

The evident solution is, a technical supporting department was established. It specified responsibilities of each sub-project, and instructed participant behaviors during project implementation.[40] In this way, organizations and sections are assigned with specific duties, and they can held conferences for coordination

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before the exhibition begins. In the meeting, conferees may be the local administration, the environmental department, stakeholders, etc. The context of discussion could be the topics of exhibitions, the design and execution of programs, the planning of issues and the adjustment of instructions, as well as the notice on local norms, natural and cultural conditions. By discussing in meetings, problems resulted from the unfamiliarity of local conditions can be solved.

There are also solutions made by participants instead of the technical department. For example the solution of concrete disposal. Concrete gives audience good feelings such as simple, thick and strong, however it can not be directly reused and recycled. Therefore, the recycling period targets on grinding concrete wastes, then the mix of small parts can be used for other purposes.

(figure 5. the Hamburg Pavilion, futurearc.com.)

On energy saving and carbon reduction, the Hamburg Pavilion was a typical case. **(figure 5.)** The sustainable measures reflected in many aspects.

One is, the building can be disassembled into sections so that each parts can be easily transported to the exhibiting site and rapidly assembled. According to Diem M., the sustainable technique is low-tech rather than high-tech.[41] So the equipment was relatively simple and easy to use.

Moreover, Qian S. indicates that, the segregation boards inset into the roof and walls are made by polymeric foam, which costs RMB3000/㎡.[42] So the polymeric foam is not expensive. Furthermore, even polymeric materials are artificial, most of them can be biodegraded, and few can be degraded by grinding or under a high temperature. For achieving less expenditure and safe disposal, the application of ecological friendly board in Hamburg Pavilion is a good example of sustainable exhibition.

It cannot be denied that in this building the high-tech was also adopted. For example, an filtering facility is installed for providing fresh air, because visitors had complained that the space is not airy and sometimes dusty.[43] Actually, this filtering facility also helped to clear bacteria, so the health of audiences and sanity of spaces can be guaranteed.

Apart from the Hamburg Pavilion, there are other classical programs in the Expo 2010 that contribute to improve the sustainable level of exhibitions, for example the French Pavilion. **(figure 6.)**

Named 'the Sensual City', the French Pavilion is covered with a reticular shell. Plants were twining vertically on steel frames of external walls, a garden was built on the rooftop, and a pond was created and surround the building. By this way, the capacity of the construction was greatly increased, therefore the building can resist extreme climates and weather. At the mean time, the adjustment of temperature and humidity by vertical greening and the pond of water could create a more comfortable climate inside the pavilion, thus the weather of external and interior could be balanced. The alleviation of hot or cold weather can bring about physical and mental health, so it is benefit for people who lives in the building.

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(figure 6. the French Pavilion, dezeen.com.)

Due to the relatively completed regulations of the Bureau of Coordination, sustainable measures are plenty. For example, in the exterior of the Cultural Center a pedestrian was built as a boulevard. According to archdaily.com, the pedestrian is called 'Sun Valleys' and served as the central axis of the entire landscape of Shanghai Expo. **(figure 7.)** The dome of the boulevard was made by valley-like panels that can collect the water of rains.[44] After being collected, the water resource were reused after purification. Reused water is widely adopted in exhibitions, such as adjusting temperature and humidity of indoor environment, flushing the toilet, irrigating grasslands and vertical plants, etc. By this way, the consumption of electricity is controlled, and the emission of greenhouse gases (e.g.carbon dioxide) is greatly reduced.

(figure 7. 'Sun Valleys', archdaily.com)

Besides, sustainable exhibition can be seen in the India Pavilion that, bamboo, instead of wood, was used as the building material for top roofs. The Indian Pavilion had creatively achieved a combination of low-cost, ecological-friendly and the strong ability of pressure-bearing. The creativity is reflected in the materials use, because bamboo is an ancient material for traditional Indian buildings, and the

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resource is abundant in the South Asia. Moreover, compared to traditional woods, bamboo has many advantages.

According to the Hardwood Manufacturers Association, merits and defects of the hardwood and bamboo were specified.

On maturity periods, it takes 40-50 years for hardwood, but only 5-6 years for bamboo.[45] So there will be a longer time to grow hardwoods. However, hardwood furniture may last for 125 years but bamboo furniture only lasts for 30-50 years.[46]

Energy consumption during hardwood manufacturing depends on the technique of sawing. But for bamboo, even machines are applied, the energy use is little. It is because bamboo products have lighter weight than hardwood ones, and small components of bamboo furniture are usually bonded by resins while large pieces are strengthened by ropes.

As for gas releasing, few carbon dioxide is released by hardwood, and minimal odour is from resins when gluing bamboo.[47] Considering the carbon footprint, both of them can absorb carbon when growing. If sourcing locally, few carbon is produced by shipping. Once after use, hardwood and bamboo can be naturally degraded.

Like the use of bamboo, the Spanish Pavilion applied willow branches to build a basket-like structure. In this way the intimacy is strengthened between nature and audiences.

Outcomes and Lessons Learned

In conclusion, outcomes of the case can be summarized from two perspectives.

Theoretically, the Expo 2010 developed the knowledge of sustainable design and management by applying the knowledge into real-life programs. The extension of sustainable theories is reflected in the aspects of ecology, industrial and human society.

Practically, the Expo 2010 provided precious experiences and guidance for large-scale exhibitions in the future. By holding the expo, practical lessons are given for managers, participants and governments. The checklist with specific goals that each period of an exhibition should meet is updated, therefore similar problems in the future can be solved easily.

In addition, other important lessons are given as follows.

1. For every organizations and sections of the Expo or pavilions, clear responsibilities and tasks should be assigned.
2. Conferences should be held before exhibition begins for discussion and consultation. The government, monitoring departments and participants need to be attended. The consultation may include local conditions such as weather, resource, material and energy supply, factories, transports, the laws of environment protection, etc.
3. A department with strong abilities of program management should be established. A checklist of goals for each project should be made for promoting sustainability in all phases of the exhibition. To meet the requirements, departments should offer the guidance, assistance and supervision for the program execution in every aspect.
4. For large-scale exhibitions involving various participants, the emphasis is more on the organization and coordination of participant activities. For small-scale exhibitions or individual participants, the emphasis is more on the improvement of techniques and the program design ability.

Case Study 2: 'Sensual Dynamics' Project

This program is about the product design and it introduced a new concept called 'Sensual Dynamic'.[48] It includes four sub project, and outcomes are the 'Sensual Dynamic' artifacts.

According to Levy P., the design of 'Sensual Dynamic' is to design products that can feel a person's

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behavior when he comes close. Then, the product can behave upon him, attract him, and invite him to join activities.[49] By this means, the new product is the trigger and also the objective. Therefore, the interactive experience for users will be greatly enhanced at the perceptive level.[50]

It is because the increasing number of people use electronic devices that, the goal of this program is to design products that better interact with users by meeting their affective needs.[51]

To achieve the goal, this program introduced concepts called 'quality of sense' and 'quality of reciprocity'[52] and identified the relation between them and human perceptive activities, so that the concepts and the 'Sensual Dynamics' design approach can be linked. In the program, philosophical approaches were applied, for example an argument called 'Things we see determine us just like we determine the thing.'[53] This argument emphasized on mutual effects of objects and awareness. Accordingly, theoretical experiences are less convincing than practical ones, and only by the interaction with human that a thing can obtain its meaning. Therefore, design for interaction is to create meanings.

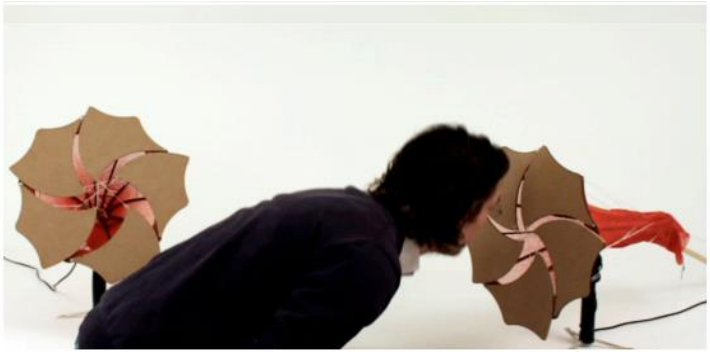
At first, human affective needs were given as sight, audition, smell, touch and taste. The ways that a product senses human were categorized as reciprocal, distant and private. Levy indicates that, feelings of sight, audition and smell are non-reciprocal and distant, while feelings of touch and taste are reciprocal and human body can feel it at local. The privacy of sight depends on the perspective that people view the thing, and generally audition and smell are public while touch and taste are private. **(figure 8.)**

	Reciprocity	Distance	Privacy
Sight	no	distant	point-of-viewed
Audition	no	distant	public
Touch	yes	local	private
Taste	yes	local	private
Smell	no	distant	public

Table 1: Qualities of the senses (excerpt)

(figure 8. Levy P.)

This classification is the starting point for further study. It will help the designer to create new interactions between users and products from the aspects of five senses. In particular, according to the general characters of audition in this case, 'Sound Flowers' is developed for changing the original characters of audition sensing. It changed hearing as 'reciprocal'. In addition, 'Be touched!' is about touch-sensitive, as the 'sensitive' pieces can feel the figures coming near before being touched.



(figure 9. 'Sound Flowers', Levy P.)

'Sound Flowers' **(figure 9.)** is a music player that can perceive someone when he comes close. As the audience approaching, mechanical petals will open and musics will play. When the audience is gone, the sound turns off

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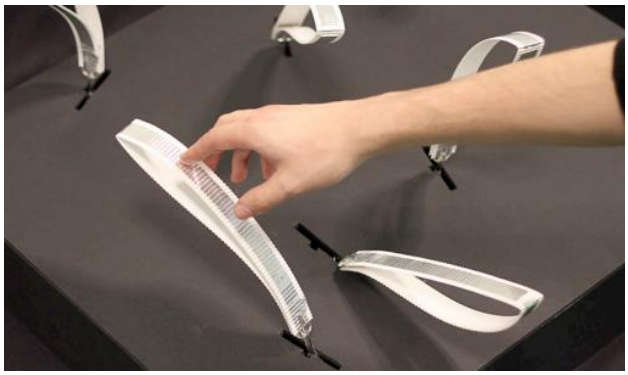
and petals will fold slowly. This machine can be used as an audio introduction in exhibitions. In the audiences survey, respondents pointed out that the audio guide is heavy and inconvenient to carry. It seems that, under the help of 'Sound Flowers' the problem that 'the audio guide is not satisfying' can be solved.

However it should be noticed that, although this design can be applicable in exhibitions that contain few people, it may not work well in big-scale ones. Moreover, due to the interference of sounds, the volume of players should be controlled.



(figure 10. 'Be touched!', Levy P.)

'Be touched!' **(figure 10.)** is a platform with several touch-sensitive pieces. For each piece, there are sensors inserted at the front and the back. If a person put the hand close to the slice, it will move towards the direction of the hand; and if one slice is touched, the others will turn the direction to the user and shake themselves to attract him. It is because of the light body and the strong sense of the slice that, the slice can be easily affected by a sense of human.

In exhibitions this design may also be applied. For instance, sensors can be put into 1:1 models which are placed near the original exhibits. In addition, they can be combined with the audio player that, when touching the model, the audience can have a direct feeling on the texture of exhibits, and meanwhile the audio player that senses the touch will begin to introduce the exhibit. In this way, the audiences do not need to carry a heavy player, and they can interact directly with the exhibits.

Analysis of Questionnaire Results

According to questionnaire results, popular displaying ways and materials of facilities can be seen.

Answer Choices		Responses	
stands and tables (open) 展架，展台		56.38%	53
models 模特，模型		48.94%	46
boards 展板		20.21%	19
screens 电子屏，放映		46.81%	44
showcase and cabinet 展柜，橱窗		54.26%	51
stage with story 场景故事		58.51%	55
Other (please specify)	Responses	1.06%	1
Total Respondents: 94			

(figure 11. 'Displaying ways you prefer', by the author)

As for displaying ways they prefer **(figure 11.)**, most of responses are 'stage with story'. A stage may include stands/tables, models and screens. The second popular way is placing exhibits on stands/tables. Compared to placing items in showcases or cabinets, visitors can closely check exhibits without the disturb of reflections on

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the glass.

Answer Choices		Responses	
Wood / Plywood 木材，板材		70.21%	66
Metal (steel/ alloy...) 金属，合金		43.62%	41
Plastic (ABS/PVC/PC...) 塑料		12.77%	12
EVA(Ethylene Vinyl Acetate) / Sponge 软卷材，海绵		23.40%	22
Glass 玻璃		60.64%	57
Cloth/ Fiber/ Cotton 布料，纤维，棉		46.81%	44
Others		1.06%	1
Other (please specify)	Responses	1.06%	1
Total Respondents: 94			

(figure 12. 'Materials of displaying tools you prefer', by the author)

For materials of displaying tools **(figure 12.),** visitors are concerned about whether a material is good for the space/environment they visit, because a space with a high eco-friendly level can guarantee their health and safety. Accordingly, natural materials such as wood, plywood and fiber/cotton, and artificial materials such as glass are popular ones.

Answer Choices		Responses	
Wood / Plywood 木材板材		61.70%	58
Metal (steel/ alloy...) 金属合金		9.57%	9
Plastic (ABS/PVC/PC...) 塑料		13.83%	13
EVA(Ethylene Vinyl Acetate) / Sponge 软卷材，海绵		38.30%	36
Leather 皮革		46.81%	44
Cloth/ Fiber/ Cotton 布料，纤维，棉		46.81%	44
Other (please specify)	Responses	1.06%	1
Total Respondents: 94			

(figure 13. 'Materials of lounge furniture you prefer', by the author)

For materials of lounge furniture **(figure 13.)**, visitors prefer materials that are good for body health instead of the environmental friendly ones. From results, wood/plywood, leather and fiber/cotton ranked higher. But leather is not sustainable due to the pollution it cause when manufacturing. That means, to improve the sustainable level, leather could be substitute by materials that has similar appearance and functions, or the processing of leather should be strictly monitored.

	cautious 小心谨慎	relaxed 很放松	cold 冷	warm 暖和	harmful 有害	healthy 健康	sleepy 昏沉	refreshing 清醒	Total Respondents
Wood/ Plywood 木材板材	5.38% 5	56.99% 53	4.30% 4	44.09% 41	4.30% 4	62.37% 58	3.23% 3	11.83% 11	93
Metal (steel...) 金属合金	21.74% 20	4.35% 4	81.52% 75	4.35% 4	10.87% 10	6.52% 6	5.43% 5	28.26% 26	92
Plastic (PVC...) 塑料	22.73% 20	17.05% 15	10.23% 9	6.82% 6	48.86% 43	5.68% 5	13.64% 12	11.36% 10	88
Glass 玻璃	61.54% 56	7.69% 7	46.15% 42	3.30% 3	5.49% 5	7.69% 7	1.10% 1	39.56% 36	91
EVA/ Sponge 卷材，海绵	5.56% 5	47.78% 43	1.11% 1	52.22% 47	11.11% 10	13.33% 12	30.00% 27	3.33% 3	90
Leather 皮革	9.68% 9	46.24% 43	8.60% 8	34.41% 32	6.45% 6	22.58% 21	21.51% 20	8.60% 8	93
Cloth/Fiber/Cotton 布料，纤维，棉	5.43% 5	55.43% 51	1.09% 1	59.78% 55	6.52% 6	35.87% 33	14.13% 13	2.17% 2	92

(figure 14. 'the following materials make you feel...' by the author)

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There are specific affective connections that respondents may have when they see a material. According to **figure 14.**, wood makes them relaxed and it is healthy, so it is a good material for lounge furniture making. EVA and sponge can also bring about feelings of relaxing and warm but they are not very healthy and makes people sleepy. Hence it is not a good choice especially for public furniture making. Leather is good for human health. However, with the current technologies, the manufacture of leather is harmful to environment. Plastic is not good for human health, and it also brings about a feeling of 'harmful'. Metal and glass is 'cold and refreshing' and makes people cautious, so they are suitable for making displaying tools. Cotton and fiber makes one relaxed and warm. As natural materials, they are sustainable and benefit for the body health. Therefore, cotton and fiber are good choices to make printing media and lounge furniture.

Answer Choices		Responses	
a quiet and clean space 空间安静、清洁		75.53%	71
safe and non-toxic tools 安全无毒的展架展台		35.11%	33
adetailed introductionfor exhibits 对展品详细的说明介绍		54.26%	51
audio guide 语音导览		37.23%	35
clear guides and simple maps 指向标清晰，地图简单		73.40%	69
Other (please specify)	Responses	0.00%	0
Total Respondents: 94			

(figure 15. 'services you mostly cared about', by the author)

As for the aspects of facilities or services they mostly cared about **(figure 15.)**, a quite and clean space and clear guides (or simple maps) ranked higher. It is because a clean space is good for visitors' health, and a clear guide or simple maps can help them finding exhibits easily.

Answer Choices		Responses	
displaying tools and shelves are loose 展台展架老化松散		26.88%	25
rooms are not airy (not refreshing) 不通风不透气		62.37%	58
no natural lights, or no plants 没有自然光，没有植物		32.26%	30
no interesting activities 没有好玩的活动		23.66%	22
no seat to take a rest 座椅太少没法休息		46.24%	43
confusing routes/ guide marks are not clear 路线很乱，导向标不清楚		61.29%	57
Other (please specify)	Responses	0.00%	0
Total Respondents: 93			

(figure 16. 'factors you are not satisfied', by the author)

For the factors that generally not satisfying **(figure 16.)**, the serious ones are: space are not airy, and routes are confusing. Natural lights seems to be less important. As facilities are mostly new and safe, few people are concerned about the safety of displaying tools.

Conclusions and Recommendations

From this study, approaches are given on the application and combination of sustainability and affective engineering in exhibitions. Conclusions and recommendations can be given to the contemporary exhibition design management in aspects of sustainability and human affective needs.

To realize sustainable development, the life period (from material selection to waste management) of exhibitions and facilities should be properly planned. Material and energy usage should be reduced by

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improving technologies, adopting dis-assemble facilities, and enhancing the efficiency of resource utilization and recycle. Besides, facilities and services need to be compared to sustainable evaluation models and be perfected. Before exhibiting, design behaviors should be regulated and supervised under certain standards and accreditation.

To apply affective engineering, visitors' desires should be specified. By collecting human feelings on materials or designs, database and computerized mathematical models can be built based on Kansei Engineering System and Human Living System. By inputting keywords of exhibition theme and visitors' needs into the calculating system, the appropriate materials, facilities and furniture can be selected.

To combine sustainable strategies and affective engineering in exhibitions, the vital step is to build databases and set up matching rules. In material selection, materials that meet sustainable standards should be compared to human affective feelings on them, and materials that audiences prefer should be tested by sustainable models. Then, the less-sustainable materials should be substituted, or their manufacturing process should be optimized.

Finally, to make a better exhibition, the focus should be more on the management instead of design. Specific departments should be built for coordination and supervision. Before the exhibition begins, conferences should be held for consultation.

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