Research on Interactive Fibre Art and Design from the Perspective of Interdisciplinary Innovation: *With Design Cases in Teaching Practice*

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Abstract— Fibre Art and Design emerged from the development of ever increasingly comprehensive conceptual Fibre art. This paper examines several current fibre artworks from an interdisciplinary perspective, assorted categories of technology used commonly in the studied Fibre art and design works, from hardware such as sensory devices to digital software. This suggests interactive fibre art and design can further enhance viewer sensory experience with meaningful artistic expression that are relevant to contemporary social trending topics, commercial requests, and natural elements, through broaden in-depth cultured aspects. The study presents two fibre art and design case studies in teaching practise for analysing practical and teaching methods.

Keywords- fibre art and design; interdisciplinary innovation; interactive expression; teaching practice

1 INTRODUCTION

Fibre art today has developed into a comprehensive interdisciplinary artistic discipline, encompassing many essential elements in both art and design, that are closely relevant to the needs of contemporary society. As a result, the concept of Fibre Art and Design naturally emerged between the interactions of current technological and social development. The field of fibre art is constantly experimenting with new material technology, mechanical and electronic engineering, computer science, new media and so much more. The trend of art and science fusion, promotes innovative exposition in the neo handmade culture era.

Traditional fibre art can be relativity homogeneous in its presentation, many artists tend to use the language of fibre materials in constructing and presenting work by emphasising on the aesthetics of symmetry and unity. The concept of 'fibre art and design' has thus become an inevitable product of the interaction between the current development of the discipline and the development of society. [1] as technology and materials continue to iterate, designers are rapidly integrating new media and interactive art with fibre materials from an interdisciplinary perspective, combining human-computer interaction to the otherwise static fibre artworks, thus giving them an interactive appearance. The addition of interactive properties makes the

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fibre art works more cutting-edge, conceptual, innovative, that brings a new sensory experience that is different from the static experience from the past.

Along with the trend towards the fusion of art and science, the field is constantly experimenting with material technology, mechanical engineering, computers, electronic engineering, new media, and many other disciplines, thus promoting the presentation of new styles and styles of handmade culture in a new era.

2 THE PATH TO INTERACTIVE EXPRESSION OF FIRBRE ART AND DESIGN

The integration of art and technology is becoming increasingly adjacent. The technological advancement offers new possibilities in the development of art, with traditional art constantly elevating its connotations, to adapt its practices in digital technology is inevitable. Digital technology is based on the basic model of binary coding system to process and transmit information through hardware devices. [2] Practitioner handle information by coding input, processing, and export, supported by digital equipment to realise human machine interaction between the artwork and viewers. The route to the realisation of Interactive expression is mainly based on using coding languages to set up interactive responses through various type of sensor transmitters to triggering interactive signals, concluded by the use fibre artworks to convey interactive contents to the viewers.

2.1 Types of Sensors

The sensor is the main input unit in an interactive device, for detecting changes in the surrounding environment. By converting information into signals according to certain rules, so as to meet the requirements of information transmission, processing, storage and record. With many types of sensors available according to different applications, common types of sensors used in fibre art are as follow (Table 1).

Table 1 The main classification of sensors

Sense Organ	**Sensor Category**	**Sensor Name**
Vision	Photosensitive sensors	Infrared sensor UV sensor Fiber optic photoelectric sensors Color sensor
Hearing	Sound sensors	Acoustic sensors Fiber optic microphone
Touch	Thermal sensors	Infrared sensor State change sensor Mechanical sensors
Olfaction	Gas sensors	Gas sensors such as gas components
Taste	Chemical sensors	Enzyme sensor Microbial sensors Bio tissue sensors

2.2 Types of Programming Languages

Three main types of programming languages are most commonly used in the interactive representation of fibre artworks. Arduino is a combo vehicle that includes both the hardware (Arduino motherboard) and software (the Arduino IDE). The programming language is relatively simple and user-friendly, constructed on an open source simple I/O interface and has a processing / wiring development environment using languages that are similar to Java and C coding language, but more practical. Open Frameworks is a creative programming language developed by the Parsons School of Design, the C++ open-source code that can be used on diverse platforms, as a more accessible and straight-forward open-source framework for developers. Both can be quickly mastered by users for the creative needs of interactive expression in the fibre arts. As a process-based software, although it is highly efficient, it is not without drawbacks, such as incomplete documentation and a relatively over complex operating system for desired visual effects. Processing is another open-source program developed specifically for digital art and visualisation design, which was originally developed with the intentions to increase user interest towards programming. Data visualisation, for example, is a very important output in which Processing can be used in the field of design. Compared to Open Frameworks, Processing is compatible with a wider range of operating systems, such as Windows, MAC OS, Linux and Android.

3 CREATIVE TECHNIQUES OF INTERACTIVE EXPRESSION IN FIBRE ART AND DESIGN

As art and technology continues to blend, interactive expressions of fibre art increasingly emphasise on interactivity and viewer experience compared to traditional art forms. Supported by the application of technology, artists incorporate multidisciplinary contents into fibre art, giving it a new form of artistic language. The common methods used to induce interactive behaviour with the viewers are often by introducing basic senses of sound or light by multimedia technologies. [3] This combination can be explored on a number of levels: presentation of cultural forms and phenomena, reflection on emotional resonance with the audience, focuses of social hot issues, reflection on commercial aspirations, and exploration of the natural wonders.

3.1 Viewer Emotional Resonance by Interactive Technology

Outstanding interactive fibre arts are able to provide more artistic humanistic discretion, delicately interpreting the spiritual needs of people by means of unique flexible materials. [4] Emotional resonance refers to the process whereby the viewer feels and accepts the message conveyed by the object, thus generating a psychological activity similar to that of the creator. According to Maslow's Hierarchy of Needs theory, when a user's needs are relatively satisfied at one level, he or she will pursue the needs at a higher level. [5] In contrast to the traditional use of static fibre art, interactive fibre art focuses more on the emotional resonance between the experiencer and the artwork and relies more on the effect created by its surrounding. This psychological effect, generated outside the artwork, allows the viewer to create a viewing experience that goes beyond the artwork itself, allowing the viewer to stimulate their own

imagination to make emotional associations, creating an artistic resonance that engulf the fibre art with warmth and affection.

3.2 Social Topics Reflection and Exploration by Interactive Technology

Interactive fibre art should be the representation beyond simple visual imitations, it is also inclined to reflect deeper connotation in association with current social issues and public concerns, provoke viewers' thought and reverie. Artists then are more able to encapsulate both wisdom and viewpoint into the artworks, discussing concerns such as environmental issues or globalisation. This type of fibre art extends from art to society and is no longer confined to its own physical form or the technology itself. Distinct from the traditional static fibre art, that are created mainly based on visual effects, the viewers of interactive fibre arts will therefore experience differently from the atmosphere created by the artworks, associating the language of fibre materials to social topics differently.

3.3 Commercial Aspiration Analysis and Fulfilment by Interactive Technology

The interactive expression of fibre art is an artistic manifestation of multidisciplinary proficiency, requiring high level of aesthetic and technical knowledge, and the abilities to collaborate. [6] These collaborations are often based on clear commercial demands. Interactive fibre art brings the consumer, the commercial space, and the artwork into the commercial domain as one. In the commercial space the consumers can be divided according to their behaviour pattern: consumption behaviour and non-consumption behaviour. [7] Consumption behaviour can be divided into purposeful and non-purposeful consumption. The substantive function of interactive fibre art in commercial spaces is to allow consumers to experience the commercial concept conveyed by fibre art as a vehicle, which in turn endorse the value increase of their brand.

Table 2 Schematic diagram of different luminescent materials

Experiment materials	**LED strips**	**EL cold light mood light**	**Plastic fiber optic fabric**
Light source size	5MM/Wide	3MM/Wide	5.5MM*5MM (Single)
Power supply mode	Battery powered	USB Powered/Battery powered	USB Charge
	AAA Battery*3	12V Positive and negative pole lines / AAA Batteries*2	1300mAh
Power	1M/4.8W	1M/0.2W	5V-1A
Volume (CM)	6.1*3.7*2.0	6.0*3.5*2.5	10.5*4.0*1.0
Appraise	The brightness of the lamp beads is too harsh	It is not conducive to optical fiber light conduction	The brightness of the lamp beads is adjustable

In a practical design project, in response to a brief from a fibre-optic manufacturer in Guangzhou, China. The author's team developed a set of conceptual fibre-art garments for commercial showcase (Fig.1). The process was divided into four modules, namely the design and creativity module; fibre material development; the hardware application of sensors and Arduino programming module, corresponded to the four teaching modules, together they contributed to a complete process of interactive expression of fibre art. The research revealed that the commercial needs of the manufacturer were not the usual ready-to-wear products, but conceptual works aiming for strong visual impacts, a sense of presence and the ability to make a statement in the commercial space. Therefore, the post-graduate students were encouraged to consider the commercial demands and its association, extracting lighting elements, such as curved forms, to create visual effects that are innovative, with a sense of high technology. The lighting effects from the inspiration board were used as reference for the lighting effect on fibre materials. It was established that the LED strips and electro-luminescence were not suitable to attach to the photoconductive fibres, due to their characteristic in low elasticity. As a result, LED lighting beads were chosen for the desired effect for its individual light source quality. Considering diversity in lighting and colour effects (Table 2), the light emitting ends of the fibre optic was trimmed in conjunction with leached fibre technique to enhance the contours to achieve a dotted pattern effect (Fig. 2). In the programming module, Arduino is programmed on the fibre optic's own motherboard, the parameters for the changes are set and the light effect is adjusted by buttons, enabling changes from dark to light with regular patterns. Enable to enhance the interactivity experience, in the sensor application module, infrared motion sensor was applied, so viewer can trigger the sensor to form interactive behaviour with the artwork through various detectable movements such as hand waving. At this point, the process of realising the interactive expression has been completed through research and exploration in four modules of the integrated research development.

Figure 1. Runway Picture

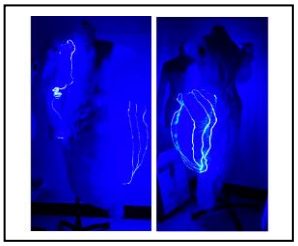

Figure 2. Fabric Version

Figure 3. The selected chemical fiber

3.4 Representation of Natural Wonders by Interacitive Techniques

Fibre art has its unique origin in nature, hence related topics naturally became a source of inspiration for fibre artists. Even with the rapid development of urbanisation today, the incorporation of nature is still highly valued in man-made art forms. The natural wonders as the subject matter in fibre art has evolved beyond merely imitation, the perception and interpretation of the natural elements by the artist is now embodied with the interactive technology.

Table 3 Basic parameters of polymer optical fibers

Sample	**A**	**B**	**C**	**D**
Diameter/(mm)	0.25	0.5	1	3
Product Category	Side surface illuminated fibers	End-face luminescent fibers	End-face luminescent fibers	End-face luminescent fibers
Core Material	PMMA	MMA	PMMA	PMMA
Cortical Material	PMMA	PMMA	Fluorescence	PC
Attenuation Impairment /(dB.km^{-1})	≤350	≤250	≤250	≤700
Operating Temperature /(˚C)	-55~70	-55~70	-55~70	≤150
Elasticity	10 times the diameter	10 times the diameter	10 times the diameter	10 times the diameter

In the creative design module, the post-graduate student team was guided to draw inspiration from photographs of cosmic nebulae, transforming the celestial objects in a symbolic way by combining them with light-conducting optical fibres for an interwoven manner, echoing the light at the end of the optical fibres through the gaps between fabric and the optical fibres. In this way the splendour of the nebula is conveyed by allowing the viewer to experience the artistic rendering of starlight in fibre art.

In order to realise the above idea, the creative team experimentally compared the types of optical fibres selected in the fibre materials experiment module. The optical fibres used for the experiments were mainly PMMA and MMA polymer fibres. Polymer fibres are more flexible, slender, soft, lightweight, large in diameter, easy coupling, non-conductive and can be easily connected to the light source. [8] After the comparison of four optical fibre materials (Table 3), it was found that samples B, C and D are all end-emitting fibres, for the fibre transmit light from input end to the exit end through full light reflection, and the light efficiency of these materials was not found to be as desirable in the epidermal experiments. On contrary, sample A as a surface-illuminating fibre, transmits light not only from the endings but also along the light transmitting surfaces, creating a side-illuminated effect that is richer and more delicate. Moreover, the fibre itself is also more flexible and suitable for weaving with other fibres. For the outcome, sample A was chosen to create the sparkling light effect of a stars.

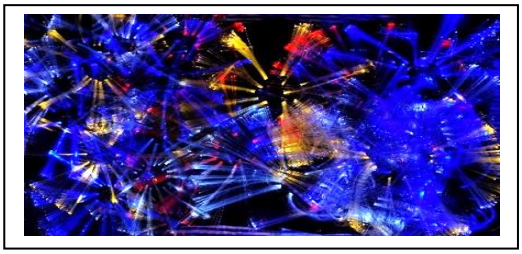

Figure 4. Myriad Stars

To further enhance the extravagance of the fibre material and to enrich the representation of the natural scene of “Myriad Stars”, the postgraduate students also experimented with five different materials in addition to the light conducting fibre for a better effect. The optic fibres were evaluated and ranked according to their suitability (Table 4). Evaluated in the table, the chemical fibre mix fabric coated with dark blue pearlescent glitter coating (Fig. 3), was spliced, and cut, to enable threading with optical fibre into the cut outs to be bonded. The fabric is then connected to the light source in consideration with the properties and processes of optical fibre and leached fibre technique (Table 4) to create a rich array of lighting effects. The combination of the Arduino programming module's automated control and the infra-red sensor switch allows the piece to shine with the touch of hand, thus giving a more subtle “starlight” effect (Fig. 4).

Table 4. Sorting of different fabrics

Fabric Category	**Fabric Composition**	**Light Transmittance**	**Stiffness**	**Fit**
1. Woolen fabrics	Cotton-wool blend	3	4	4
2. Denim	Cotton 100%.	2	5	5
3. Knitted fabric	Chemical fiber/wool blend	1	2	2
4. Chemical fiber fabrics	100% polyester	5	1	1
5. DuPont paper	DuPont paper	4	3	3

4 CONCLUSION

Fibre Art and Design is a comprehensive concept that integrates art, design and technology. Artists, designers, and engineers use interdisciplinary innovation to break through and explore new path of intelligent means to drive the development of fibre art. Interactive expressions has given wings to the path, its core value lies in the act of interaction with the viewer, by not only adding a sense of experience and participation to the audience and enriches the expression of fibre art, but also broadens the scope of application of fibre art, merging the artist's dimension of the work with the designer's dimension in product. The four-step teaching module explored

this development process: design creativity module, fibre material experimentation module, Arduino programming module, and sensor application module, is a high degree of integration between research and teaching, becoming a method of art creation that organically integrates multidisciplinary content.

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