A Study of Usability Design of Baren Products

Ke Zhang(✉) and Xiaoli Dong

School of Design, South China University of Technology, Guangzhou 510006, People's Republic of China
kezh@scut.edu.cn

Abstract. In recent years, with the rapid development of the domestic cultural economy, the development of the printmaking market is also at a good opportunity. As an important rubbing tool in the production of prints, baren plays an important role in the effect of printmaking. The development of printmaking determined that baren has a significant commercial development value and design research significance. However, the user may experience hand soreness, chassis edge puncture paper, chassis wear during the process of using the baren to rubbing prints. This paper creatively introduces the usability analysis into the design research of baren from the perspective of user experience.

Keywords: Print rubbing tools · Baren · Product design · User experience · Ease of use

1 Introduction

Printmaking is a comprehensive art that combines painting, engraving and printing with a knife as a substitute for a pen. There are two ways of engraving rubbings, one is to use the engraving machine for rubbings and the other is to use baren for manual rubbings. Compared with other paintings, the charm of printmaking lies in its "craftsmanship" and "operability". In the process of printmaking creation, as shown in Fig. 1, rubbings are used to express their thoughts and the world in their eyes. Hand-printed prints can improve the coordination and use ability of hands, eyes and brain, enhance the control ability of hands, and make the image more in-depth and detailed [1].

2 Manual Baren

There are very few articles on the design and research of baren products in domestic and foreign literatures, and most of them are about the content of print art. Only during the research of printmaking, they mentioned some information about the appearance, materials, production process, etc. of baren products. In general, there is no systematic research literature on baren products, whether foreign or domestic. Therefore, the baren product design research based on man–machine force analysis not only has the innovation of product design practice, but also a theoretical academic innovation attempt.

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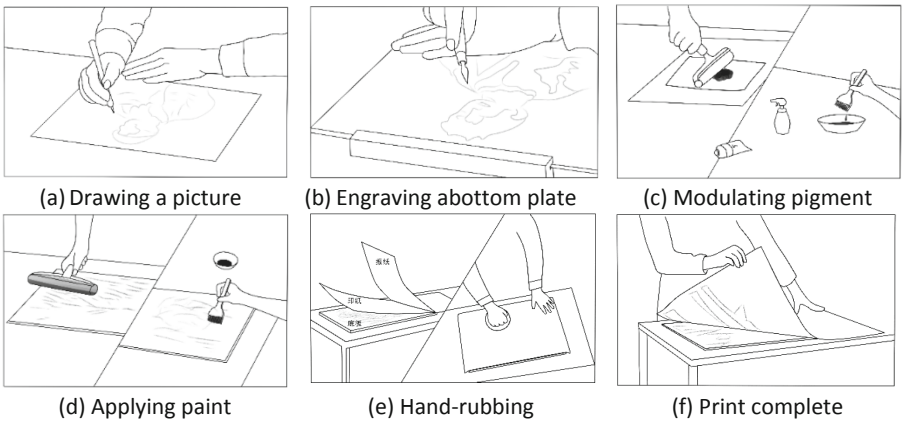


Fig. 1. Manual printing flow chart of printmaking.

On the one hand, the baren products provided by this research topic are visited by the painters in the form of field visits, obtained in the printmaking village and the Chinese New Year paintings base, and on the other hand through online shopping. Then through the desktop research method, collect the data related to the baren products on the network, organize the baren product introduction and user review data on the e-commerce platform, and compare and analyze the material and user evaluation, and provide the baren products. The information is summarized as following and illustrated in Fig. 2:

According to the market research results, baren is called differently in different places, but its functions are similar. Up to now, baren can be roughly divided into two categories: traditional baren and modern baren [2].

China is the first country in the world to invent engraving and printing, and the birthplace of printmaking. Tangzi is a tool for embossing paper in the printing of ancient Chinese New Year paintings. Tangzi is made of old palm tree bark. Of course, some exquisite Tangzi also use horsetail, which has few impurities and is durable [3].

The traditional Japanese printmaking method uses a tool called "Tuobao", which is a baren. It is a printing tool developed by Japanese prints based on the techniques of studying ancient Chinese prints. It is also loved by Western printmakers. The traditional Japanese baren is made of bamboo skin (required bamboo skin are large enough and complete), wood boards and hemp ropes. Compared with the traditional Chinese Tangzi, the traditional baren of Japan has the characteristics of strong force and control flexibility, which is very suitable for the use of a small number of watermark prints [4].

Nowadays, many artists use a mushroom-like baren. This tool is preferably made of hard wood. Both ends of the head and the handle can be used. The head is used to grind a large area, and the handle can be used to grind a part of the work. The general specification is that the handle is 10 cm long, the chassis diameter is 4.5 cm, and the weight is 30 g. South Korea has improved its styling on the basis of traditional wood mushrooms. On the basis of South Korea, Germany added a 5 mm thick felt base to the baren friction surface, which can be used for imprinting or other purposes.

Fig. 2. Baren products across the world.

Steel ball baren is also a newly invented printing tool in recent years. It is divided into two types, one is that the beads can be rolled, and the other is a steel ball that cannot be moved. The surface is smooth, wear-resistant, and has a certain pressure, so it is relatively easy to use. But these two have one thing in common. The product form is more clumsy and expensive. The market price is around 1000 yuan, which is not very popular. Compared with the thicker metal baren made in China, the Japanese baren is lighter and made of wear-resistant resin and stainless steel beads. When printing, you need to exert relatively large strength, but you can print beautiful effects. If you print a large work, or a large number of repetitive prints, your hands will feel tired and painful.

The invention of plastic baren originated from Akira Korosaki, a famous Japanese print artist, who designed plastic baren on the basis of traditional baren. The innovation of baren is that the friction surface of the chassis can be removed and replaced with a new one after long-time wear and tear. When the plastic baren evolved into the Chinese market, it became simple but difficult to use without replaceable friction surfaces.

During the investigation, a wooden baren was obtained from Taiwan. It has a smooth wooden surface, which gives a very comfortable feel, and the side surface of the chassis has a concave and convex surface, which makes it easier for people to hold. The handle looks a bit awkward compared to the chassis. McMade's painting company sells a baren with wood-bonded fabric. This fabric has a smooth texture and is suitable for grinding, but the wooden structure is too simple, the handle is uncomfortable to use, and the user's reflection is easy to loose.

To sum up, due to the uncertainty of pressure in the process of baren's use, it is difficult to analyze the force of man-machine interface by establishing a more objective virtual model. Therefore, this project intends to study the usability test by means of satisfaction test and fatigue index test of physical prototype. The fatigue test was evaluated by the reduction of the right arm grip strength before and after the experiment.

3 User Requirements for Usability of Baren Product

3.1 Objectives and Methods

What kind of baren can solve the above problems? Based on this question, this chapter carries out an experiment combining observation and interview to explore users' perception of baren product usability standards.

Identify and Segment Target Users. In the early stage of baren's design and research, users should be stratified and target users should be established. Only by combining the needs of target users can products satisfying target users be designed [5]. Baren's users are widely distributed, including primary school students, middle school students, high school students, undergraduates, graduate students, professional printmakers, amateur printmakers and so on.

The users involved in the survey recruited 20 master's and undergraduate students (including 14 females, average age: 23 years old) with experience in making woodcut prints from the school of design of the author's university. Participants were required to: (1) be able to critically analyze the form and function of all products; (2) be able to discuss usage scenarios without experiencing future conceptual design; and (3) be able to speak out their needs in conversation.

Baren Product Design User Survey. From the perspective of psychology and behavior, what people say or think is often different from what they do [6]. Therefore, semi-structured interview method and observation method are combined to design survey method. First, we conducted a semi-structured interview to understand the target users' feelings and opinions on existing baren products in the market, and sorted out the problems that users encountered in the process of using baren products. Then, in order to facilitate discussion and obtain users' use of the product under the most real conditions, baren products will be provided for users' operation experience during the interview, so as to observe users' use more comprehensively. The combination of these two survey methods can better analyze the real needs of users in the process of experience and the potential needs hidden under the surface behavior.

3.2 Baren Product Usability Attribute Induction

All contents of semi-structured interviews and observations were recorded, and then iterative analysis was carried out using grounded theory research [4] to obtain the usability attributes of baren products. The records collected about 70 items, only 35 of which met our research questions and were considered valid.

Through open coding, these contents are grouped into similar patterns without any presets, and are arranged into 10 patterns according to the similarity of the contents. For example, from the phrase "plastic baren will wear out the chassis soon", it can be deduced as "the wear resistance of the product materials" that is one of the powerful usability attributes. Then, it also can be analyzed what product elements are associated with each usability attribute, and group them by the mode of the axial coding in terms of how the user behavior is derived. In this way, the two levels can be identified that included four product usability attributes, as shown in Fig. 3.

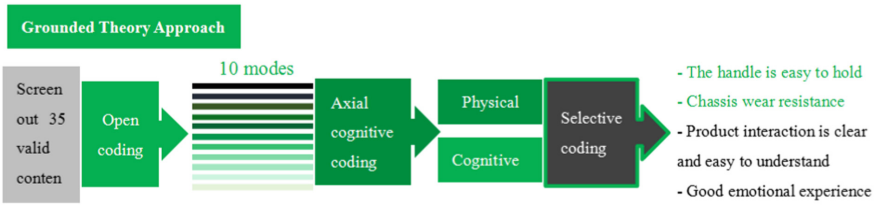


Fig. 3. Analytical research method for obtaining user's demand for usability of baren.

From the results of interviews and observations, it can be found that the usability of baren products can be attributed to the usability at the physical level and the usability at the cognitive level. The usability of the physical level is summarized as the handle is easy to hold and the chassis is resistant to wear. The usability of the cognitive level focuses on the ease of use perceived by the user, and users' expectations for cognitive usability mainly include product interaction of a clear and easy to understand and a better emotional experience.

Usability Attributes of Physical Level. ***The Handle is Easy to Hold***. Users reflected that when using baren products, the handle design was unreasonable, which caused an uncomfortable experience for users. For example, there will be a situation of grinding the hand, and the dimensional distance with chafing chassis is too narrow, so that the finger is completely gripped, and a feeling of pressure will appear; the palm is in a state of no support during the process of moving the rubbing in the grip state. The angle between the arm and the palm is too large, causing the wrist to withstand greater pressure and causing soreness. This kind of easy use that affects people's physiological acceptability should also be analyzed from the perspective of ergonomics, so as to design a baren handle form that is more easy to use. Therefore, this phenomenon and demand can be summarized as the physical "handle is easy to grasp".

Chassis Wear Resistance. Especially the domestic plastic baren used for a long time, the chassis will appear partial wear, and the Japanese plastic baren, in order to maintain the durability of the product, the design for the replacement of the chassis. Most college students use plastic baren, so it is generally reflected that they hope baren can be more wear-resistant and minimize local wear.

Usability Attributes of Cognitive Level. ***Clear and Easy to Understand Product Interaction***. In the process of operating baren, good communication between products and users is essential. The quality of product interaction affects the user's usability experience. The clarity and understanding of product interaction is reflected in the form of the product. Specifically, the structure of the product makes it easy for the user to understand how to operate and guide the user to use it correctly, so as to avoid the user's unfamiliar user experience in understanding the way the baren product is held.

It has been observed that the operator's holding method for the same product is different, as shown in Fig. 4. For example, users use plastic baren mainly in two ways, and due to the size of the palm is not the same in both men and women, it leads to the male adopting the holding mode. The female adopts the holding mode, which shows that the original plastic baren product form is lacking in guiding the user to use

correctly. Just based on their own understanding and exploratory grip, the user experience is different from the different grip styles. Therefore, in the design of the new baren product, it is urgent to design a simple and clear product interaction interface to guide the user.

Fig. 4. Example of different ways of baren operation.

Better Emotional Experience. The design of the product not only has to have practical functions, but if it can convey the product semantics which are more in line with the user's psychological needs through the point, line and surface of the product, it can bring a better emotional experience to the user [7]. When users use baren, especially the ugly baren or the cheaper baren, they will feel that they are not confident in their use, and couldn't reflect the own taste. Even if they are preliminary learners, they may not be used frequently. They also have high expectations for the design of the new baren. For example, if the design of the baren product can be conveyed in the popular animation culture, traditional culture, etc. through the shape, color, material, etc., or it may look more personalized and fashionable. A strong look is more attractive to them to buy and use.

4 Analysis of Factors Influencing Usability of Baren Product

The usability of baren products is affected by many factors, including physiological state and behavior, psychological characteristics, using environment and basic functions of the products. These factors are analyzed in detail in order to obtain the preliminary design guidelines related to the new baren product design.

4.1 Physiological Status Analysis of Users

Human Hand Size. The rubbing of baren products requires direct contact with the products by hand. Therefore, the design of the holding part directly affects the usability of baren products, and the design of the holding part is closely related to the size of the hands. In the design of new baren products, if the size of the hand is not taken into account, the size of the holding part of the product is not designed properly, which will inevitably affect the user's usability experience of baren products.

By referring to the measurement standard of Chinese human hand data, as shown in Table 1 it indicates the length and width of Chinese male and female hands as well as their percentiles. The peak at the 50th percentile is the average value, as shown in

Fig. 5. From Table 1, it can be found that the adult male with the 50th percentile has a hand length of about 183 mm and a hand width of about 82 mm. Adult female hands are about 171 mm long and 76 mm wide. The size calculation in baren product design can be based on the following set principles of product functional size:

Product optimal functional size = human body size percentile + functional correction + psychological correction [27].

Table 1. Human hand size [8].

Age group	Male (16–60 years old)							Female (18–55 years old)						
Percentile	1	5	10	50	90	95	99	1	5	10	50	90	95	99
Hand length (mm)	164	170	173	183	193	196	202	154	159	161	171	180	183	189
Hand width (mm)	73	76	77	82	87	89	91	67	70	71	76	80	82	84

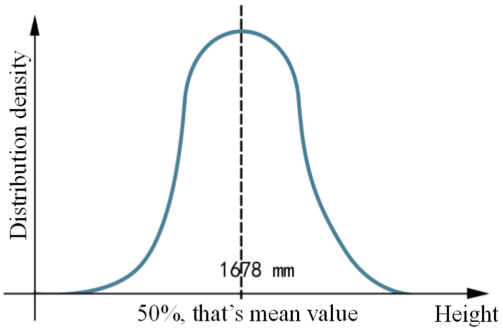


Fig. 5. Normal distribution of human body size [9].

The length of the holding part of the baren product studied in this paper is mainly affected by the palm width of the hand, as shown in Table 1 so the palm width of the hand can be substituted into the formula to calculate the length of the holding part of the product. Data are obtained as shown in Table 2.

Table 2. Baren product recommended holding area length range.

Result of holding area length range for baren product	
Maximum (male)	Product size: 82 + 0.4 (glove correction) + 0.6 (anti-slip texture parameter) = 83 (mm)
	83 + 10 (reserved movable size on the left side of palm) + 10 (reserved movable size on the right side of palm) = 103 (mm)
Maximum (female)	Corresponding product size: 76 + 0.4 (glove correction) + 0.6 (anti-slip texture parameter) = 77 (mm)
	77 + 10 (reserved movable size on the left side of palm) + 10 (reserved movable size on the right side of palm) = 97 (mm)

In the process of using baren, if the whole palm is controlled on the chassis, the chassis should be as wide as or slightly wider than the width of the palm, so as to more easily control the product's range of motion to achieve the desired effect. Therefore, using the width of the palm as the basic reference, the approximate width range of the baren chassis is calculated. The palm width dimension used here refers to the total width including the palm width and thumb width. Its total width can be taken as the human body size value input by the formula by using the width of thumb in the hands of Chinese adult male and female at the 50th centile, as shown in Table 3. The total width size data are 104 mm and 91 mm, respectively. Under the guidance of ergonomic hand size design principles, the chassis size of baren products studied in this paper was estimated, and the chassis width was about 92 mm–105 mm, as shown in Table 4.

Table 3. Total human hand width (with thumb).

Percentage	5%	50%	95%
Adult male (mm)	94	104	112
Adult female (mm)	81	91	102

Table 4. Recommended chassis width range for baren product.

Result of baren product recommended chassis width range	
Maximum (male)	Product size: 104 + 0.4 (glove correction) + 0.6 (anti-skid texture parameter) = 105 (mm)
Maximum (female)	Product size: 91 + 0.4 (glove correction) + 0.6 (anti-skid texture parameter) = 92 (mm)

In the process of using baren, most of the time the fingers need to be bent and grasped. In the extreme grasping state, only one palm area is left between the hand and the baren chassis from a vertical view, so the length of the baren chassis should be greater than the length of the palm. From the above analysis, it can be concluded that the length range of baren chassis is greater than the length of palm and less than the length of hand. The size of palm length can be obtained by regression equation of male and female hand control parts [10]. The regression equation of male palm length was: palm length (male) = 7.89 + 0.53 hand length (male), while the regression equation of female palm length was: palm length (female) = 3.20 + 0.55 hand length (female). Combining the size of male and female palm length and hand length, according to the range value principle of "take the maximum and the minimum" in mathematical calculation, the analysis shows that the chassis length range of baren product is between 105 mm and 174 mm.

Based on the above data of human hand size calculation, it can be determined that the shape of baren chassis is roughly oval. Baren products recommend holding area length greater than 97 mm less than 103 mm; The recommended width range of the massage chassis of baren products should be greater than 92 mm and less than 105 mm; Baren chassis length shall be greater than 105 mm and less than 174 mm.

It should be noted that in this paper, the parameters when wearing gloves are taken into account as a possibility correction, corresponding to the functional correction in the design principle formula, and the anti-skid texture parameters of the product are set as the psychological correction.

Range of Motion of the Hand Joints. The rubbing of baren products requires direct contact with the products by hand. Therefore, the design of the holding part directly affects the usability of baren products, and the design of the holding part is closely related to the size of the hands. In the design of new baren products, if the size of the hand is not taken into account, the size of the holding part of the product is not designed properly, which will inevitably affect the user's usability experience of baren products.

Wrist joint activity is one of the main types of hand joint activity. The range of wrist joint activity can be divided into transverse range of motion and longitudinal range of motion. The longitudinal range of motion of the wrist is palmar flexion toward the palm and dorsal flexion toward the hand, as shown in Fig. 6. The lateral range of motion of the wrist is radial deviation toward the thumb and ulnar deviation toward the little finger, as shown in Fig. 7. Figures 6 and 7 marked by many experiments in determination of activity of several limit [11], it is important to note the wrist joint can activities to the limit, but in close to the limit state of work is very tired, and keep wrist extreme bending force operating state for a long time, on each muscle in the arms of operation will also affect. Therefore, it should be avoided to keep the wrist in the limit state of joint degree for a long time [11].

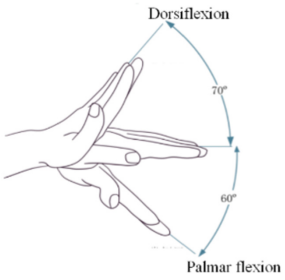


Fig. 6. Longitudinal range of motion of the wrist joint.

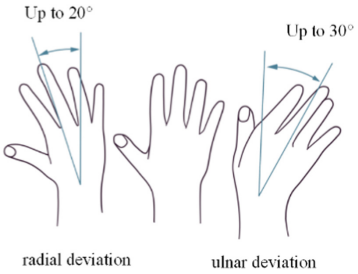
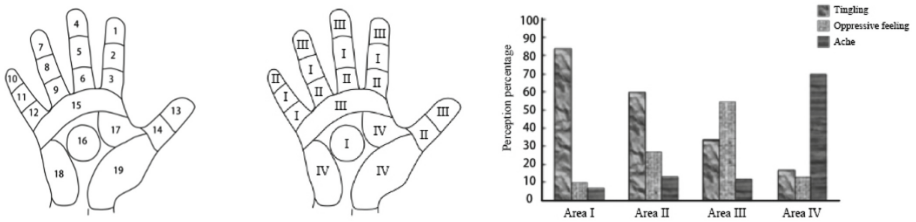


Fig. 7. Lateral range of motion of the wrist joint.

So for the wrist structure, what is the Angle at which the wrist is bent, and what is the most comfortable hand? In response to this question, the authority has proved through many experiments that the most comfortable state is when the Angle between the palm and the stressed plane is between 15 degrees and 30 degrees under the stress state of the wrist joint of the hand. If it goes beyond this range, the forearm muscles will be in an uncomfortable stretching state, and if you press hard again, the blood vessel flow may be reduced [12], resulting in numbness of the muscles around the wrist. These data conclusions are the results of long-term practice, so they can be used as a reference in the design of new baren products.

Hand area pressure perception. When holding a baren product to print a print, it is necessary to exert a large amount of strength, and the hand is deformed by the force, which causes a feeling of discomfort such as soreness, which is related to the muscles and nerves of the hand part, and due to the muscles of different parts of the hand. Differences with the distribution of nerves can also cause different pressure deformations and perceptions in different regions. Therefore, according to these factors, the relationship between the bearing capacity of different parts of the hand and the distribution of muscles and nerves should be analyzed, so as to better guide the layout of the main bearing area of the product interface of baren product and avoid the discomfort such as soreness during use.

Tao guoqiang, a master student of zhejiang university of technology, has divided his hands in detail in the research on the establishment of virtual model of handgrip [13]. He divided the hand into 19 regions, as shown in Fig. 8, in which 14 fingers were



A: 19 partitions of hand B: four areas of hand C: diagram of comprehensive physiological perception

Fig. 8. Pressure distribution in different areas of hands [13, 14].

divided into 14 regions, and the palm was divided into four areas according to the distribution of muscles and other soft tissues of the hand.

Because the tissues and structures of different parts of the hand are different, the magnitude of the force that can be sensed and withstood by different areas of the hand is also different. In areas where the muscles are more developed and the nerve tissue is less, the force that can be tolerated is greater. On the contrary, there are fewer hand muscles, but the areas with dense nerve distribution can withstand less force. The pressure that different areas of the hand can bear is shown in Fig. 8.

It can be seen from the Fig. 8 that the pressure bearing values of partitions 18 and 19 are the highest, followed by zones 1, 4, 7 and 13. Because the function of baren determines that a considerable amount of force should be exerted by hands in the operation process, the main force point layout of baren should be placed in the 18 and 19 regions with more muscles as far as possible. The application point of guiding direction control can be placed on the fingertip fingertip segments in regions 1, 4, 7 and 13, where the fingertip muscles are relatively abundant, and the first web where the nerve tissue is less. Among them, when using the finger for power control, the thumb has the strongest power control ability, so the thumb can be considered to control the direction movement.

Xia rulong, a master student of zhejiang university of technology, divided the center of the palm into four zones when studying the comfort of holding tools. Each zone has different perception of pain, pressure and pain [14], as shown in Fig. 8. The palmar and interphalangeal muscles are particularly sensitive to tingling sensation. If the design of the handle is not reasonable, the muscle between the palm and the interphalangeal will bear a lot of local pressure during the manipulation, which may cause numbness and tingling sensation for a long time [15]. Therefore, the force point of the baren product handle and the force position of the guiding direction should not correspond to the interphalangeal muscle of the palm as far as possible, as shown in Fig. 9.

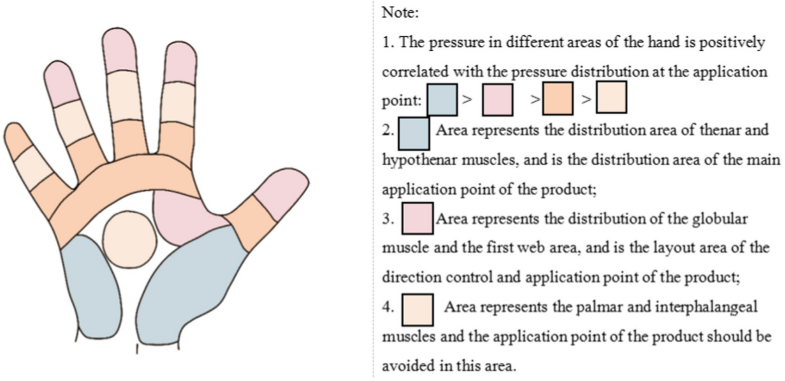


Fig. 9. Baren product force point layout.

4.2 User Behavior Analysis

Operator Posture Analysis. Based on the particularity of the rubbing print process, most of them use stand-up work. The operation diagram is shown in Fig. 10. From the analysis in the Fig. 10, the operator can take care of the larger work when using the "upright" work posture. The area can also make greater force on the hand. When standing and operating, 1. can try to control the large space; 2. The hand can make more force; 3. Effectively use the visual space to operate other parts.

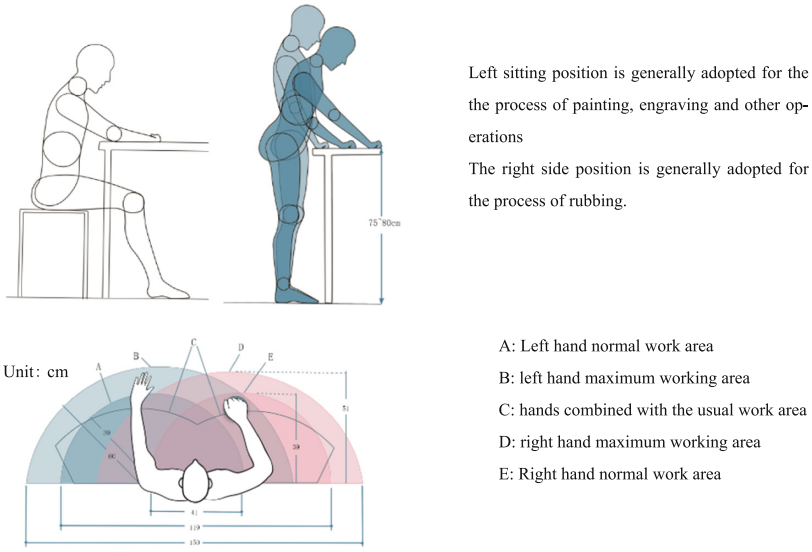
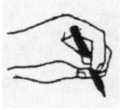
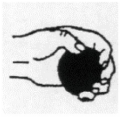


Fig. 10. Analysis of operation posture.

Different Holding Methods and Strength Analysis. Table 5 summarizes some basic ways of holding different baren products.

As can be seen from Table 5, wooden mushrooms belong to the most common incomplete holding posture. Although they are small and elegant in shape, they need fingers to manipulate, press and move, which will result in large local strength of fingers, which is not conducive to power transmission. Other baren products are held in a relatively reasonable way, and the last complete holding method in the Table 5 is the best. According to the research, the holding force of baren products changes with the distance between the top of thumb and the top of other four fingers. The holding force is greater when the finger-spacing is between 2.5 cm and 7.5 cm. The finger range is closest to that of a half-clenched fist in its natural form. For the palm, it is to try to meet the user's comfort in this form when using the product.

Table 5. Classification of different baren holding methods.

Classification of operation mode	Operating characteristics	Operational diagram	Representative product
Non-complete hold	The grip of the thumb and two fingers is close to the middle.If the palm contact grip, will cause palm discomfort.		
Complete hold	The fingers are close to the palm of the hand, and most of the fingers and the inner surface of the palm are in contact with the object.		
Complete hold	The inner surface of the entire palm grips the handle completely. Such a type of grip is often referred to as "power grip."		

4.3 Analysis of Users' Psychological Characteristics

The design of products should not only meet the practical functions of the products, but also meet the growing psychological and emotional needs of people. The inner meaning expressed by the products and the emotional needs caused by them are increasingly valued by people in the design [16]. Psychological factors affect the emotional experience of the whole product. The main judge of baren's usability is the user. Users of different ages have different needs for ease of use. Therefore, it is necessary to fully understand the psychological factors of users in order to make the product design positioning more accurate.

Professional printmakers and teachers of printmaking have high expectations for baren due to their profound artistic and cultural deposits. Primary and secondary school users prefer those products with interesting shapes, rich imagination, gorgeous colors, rich fairy tale colors and safe features. University student users attach importance to the psychological and emotional satisfaction brought by the product, such as differentiated, personalized and diversified experience. Therefore, when targeting the target audience

as a group of students in college printmaking, they should consider them as artistic students. Compared with ordinary college students, they may have more requirements for the beauty of baren products. Therefore, when designing baren products for college students, we should pay more attention to the beauty of the products.

4.4 Product Use Environment Analysis

The creation environment of the engraving is relatively dirty and messy, which makes the following factors need to be considered in the usability design of baren products:

Easy Cleaning. Oily inks and gouache pigments are used in the process of making prints. Under such an operating environment, baren's surface and chassis are likely to turn black. This determines that the outer surface of baren should be as smooth as possible and the material should be washable.

Easy to Receive. Print creation to use more tools, print baren size should be within a reasonable range, not too large or too small, and other products should be combined with the common storage space.

Versatility. Refers to the versatility of some operation modes. The tools needed for engraving creation are messy and each tool has different function. We hope to consider functional composition in the design of the new baren, so as to reduce the number of tools and make the desktop more concise.

4.5 Analysis of Product Functional Constraints

Tactile Comfort. Users report wrist pain and other phenomena when using baren. The tactile comfort of baren products is closely related to the materials, so in the later shaping of product forms, materials that can bring more comfortable tactile sensation should be considered in the selection of materials.

Durability. After using plastic baren for a long time, the chassis will produce wear phenomenon, reducing the service life of the product. The baren, handmade with bamboo skin and cloth covers, will soon wear out. This decided to consider the use of high friction resistance coefficient, the use of good performance of the material.

Less Mistakes. In print art, a knife is used to carve uneven patterns on basswood to express the work. This makes it easy for the plastic baren to break the paper on the board during the rubbing process. Therefore, users hope to reduce the chance of breakage through the shape design of the product. And when the rubbing engraving left hand to press on the edge of the board, because the plastic baren chassis thin, it will appear sharp, easy to rub in the rubbing to the left hand near the finger, causing pain.

5 Conclusion

In this paper, the research and design of baren products innovatively introduces usability analysis into the design research of baren by focusing on the usability of plastic baren. This topic introduces the concept of usability for the design and research of new baren products, and has the following results:

(1) Through market research, pre-interview and observation method, the problems of baren products at home and abroad are summarized. After analysis, the user's usability for baren products is summarized.
(2) Multi-dimensional analysis of the factors affecting the usability of baren products, combined with the basic design elements of the product.
(3) Through the induction of the usability requirements, the factors affecting the usability are analyzed.

The result of the study will be used for further design a brand new baren product that satisfies targeted users.

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