

SIGNIFICANCE OF HAND DRAWING IN EMBODYING AN IDEA

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ABSTRACT: Aiming at improving the efficiency of product development, various efforts are being made to sophisticate designs. Designers should not depend on 3D CAD, a design tool, but should reaffirm the significance of hand drawing, the origin of design, in order to supplement their decision-making and thinking abilities, which are required to produce creative designs. The greatest advantage of hand drawing is that only a pencil and a sheet of paper are needed to express an idea. This paper is organized as follows: 1) the usefulness of CAD; 2) the convenience of hand drawing in generating an idea; 3) the culture of hand drawing in preparing drawings; 4) originality created by drawing intuitive lines; and 5) the significance of hand drawing in creating an idea, keeping in mind the relationship between the basics of education and tools.

Keywords: Fundamental Design, Three Dimensional CAD Design, Hand Drawing, Idea

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1. INTRODUCTION

Design is at the core of engineering education. Design ability is necessary for engineers who wish to leave a legacy for future generations. Also, it is a joy beyond measure for designers to embody their idea, which is a manifestation of the originality and identity of the designer. An idea originates from thinking, and the compilation of thoughts through hand drawing is essential for designing an object. Whether an idea remains merely an idea or is actually brought to fruition depends on the potential of that idea.

As the use of three-dimensional (3D) computer-aided design (CAD) has become widespread, it seems that the age-old technique of hand drawing has gradually declined. An ancient Chinese philosopher Chuang-Tzu said, "Where there are machines, works using machines are generated; when such works are generated, people depend on machines (from the Complete Works of Chuang-Tzu Translated by Burton Watson, 1968)." Namely, modern tools are very useful in improving efficiency, but at the same

time, they can take control of the users and deprive them of their advantages. Chuang-Tzu expressed concern about the possible negative results of the single-minded pursuit of efficiency.

Taking this philosophy into consideration, this paper is organized as follows: 1) the usefulness of CAD; 2) the convenience of hand drawing in generating an idea; 3) the culture of hand drawing in preparing drawings; 4) originality created by drawing intuitive lines; and 5) the significance of hand drawing in creating an idea, keeping in mind the relationship between the basics of education and tools.

2. USEFULNESS AND DISADVANTAGE OF CAD

2.1. Usefulness of CAD

Simply put, the advantage of CAD is that designers can draw lines and curves as they imagine them without being influenced by their habits in drawing. Designers recognize CAD as a design support tool for drawing lines at desired positions while reflecting their

images.

However, creative design is essentially something that only man can produce and is never achieved automatically. Three-dimensional CAD is only one means to embody an idea generated by a designer's potential, and supports designers in developing their idea through interactive communication with computers. Also, 3D CAD plays an important role in product manufacturing not only as a design tool but also as the core of manufacturing information systems.

Aiming at improving the efficiency of product development, various efforts are being made to sophisticate designs. For example, for complicated shapes that cannot be expressed by only three views, drawings from multiple angles are needed. Even if it is difficult to construct a two-dimensional (2D) drawing of such a shape, a projection drawing can be easily obtained by constructing a 3D model of that shape and specifying an angle in the drawing.

As a result of the improvement of visual and graphic expression techniques, the design process of extracting creative factors from a designer's formless idea and expressing the idea on a computer screen using pointing devices such as a mouse, keyboard, or tablet will become more efficient by acquiring the skills for operating such devices. In addition, 3D CAD enables designers to model an idea into a 3D shape, to easily select colors and materials in virtual simulations, and to determine the design of the shape within the framework of standards and rules of drawing that have been registered into the system in advance. Moreover, using the zooming and free-rotation functions in preparing drawings, designers can check the model shape from every angle and make the shape understandable to those who are not accustomed to 2D drawings.

The sophisticated expression of 3D CAD model data has enabled us to convey information in a more visual and realistic

manner and to share information in a very convenient way. However, the amount of information conveyed by 3D CAD model data alone is limited; 2D drawings are still often used for conveying design information. While the utilization of 3D CAD model data is expanding, the fact remains that the design process still depends on 2D projection drawings.

2.2. Disadvantage of CAD

A critical disadvantage of CAD may be revealed sometime in the future. Designers may become much too accustomed to and dependent on the use of 3D CAD, in which a 3D shape is visualized on a computer screen, to an extent beyond their abilities and thinking, which will cause a kind of numbing of their sense of design. Namely, they may become fixated on the thought that they cannot embody an idea without using tools, thus impairing their thinking and creative abilities. Development and design are the processes of developing new technical elements and the designers' creativity plays a significant role, but the abilities based on experience are of relatively low importance. Design techniques are acquired through repeated prototyping and simulation, and the quality and productivity of development techniques depend on the individual abilities of the designers. Solutions for design problems are found through decision-making processes. Therefore, designers should not depend on 3D CAD, a design tool, but should reaffirm the significance of hand drawing, the origin of design, in order to supplement their decision-making and thinking abilities, which are required to produce creative designs.

The advantages of a 3D shape model are the realness and the clear expression of details. However, a 3D shape model is not the final drawing but merely a supplement for reviewing the entire drawing of the design. On the other hand, hand-drawn images play a very important role in understanding the total scale of the design. Therefore, designers can

achieve a more realistic understanding of their design by placing more importance on hand drawing instead of 3D shape modeling as the final goal of the design process.

Tools must continue to change and evolve with the times, but the basics of techniques do not change over time. Most engineers try to acquire creative and development abilities through technical training, but these abilities are best fostered by keen observation, association, and memory.

3. CONVENIENCE OF HAND DRAWING

3.1. Unique role of hand drawing

CAD is a system operated on computers. A design is expressed in numerical terms in CAD but in non-numerical terms in a hand drawing.

It is very difficult to draw curves with the parts working coordination using compasses. However, we can directly describe and reproduce our intention on paper using a pencil. Also, the characteristics of designers, including their sensibility, personality, and thoughtfulness are prominent in hand drawings. The unique advantage of hand drawing as a means of capturing creative images is the originality of individual designers reflected in it.

People tend to conclude whether they are skillful or not in drawing lines and curves on their own judgment as they do in other various areas, but they should not make premature judgments. There is nothing better than experience in this area, and those who were initially unskillful at drawing but have made efforts to reach a certain level have higher ability of expression than do those who had been skillful from the beginning. This is because unskillful people use more ingenuity. The skills for reproducing an idea in drawings are not generated by habitual repetition but result from the repeated and continuous exercise of ingenuity and thinking. Such training expands the range of sensibility of individual designers. Namely, ingenuity

comes from seemingly time-consuming works, and sensibility is fostered through the exercise of ingenuity. Eventually, the designers' sensibility will be reflected in the ridgelines they draw and they will become able to illustrate their ideas more clearly.

Designers will suddenly become able to draw the lines they want after experiencing many similar procedures that require time and effort. The discovery of their own range of sensibility leads to total accuracy in their drawings. As a result, there will be a clear difference in their potential for growth with time between designers who use CAD after full awareness of the time and effort required in hand drawing and those who have used CAD from the beginning.

3.2. Relationship between hand drawing and thinking

The significance of hand drawing is challenged when designers' thoughts and images are not organized. Seemingly wasteful activities such as drawing unnecessary lines and dots are important in embodying an idea. Also, man is said to gain a broad perspective by grouping individual elements in his field of view.

What should be excluded in the thinking process is preconceptions and stereotypes, because designers' assumptions interfere with their creative activities. Focusing on this point, designers are less likely to exhibit their originality but tend to depend on selecting options when they are using CAD. Following a formalized pattern of behavior, they may even have to modify part of their idea to fit the CAD functions instead of expanding the images they have.

The thinking process in creative activities consists of superimposing a series of ambiguous drawings. A new idea is generated when designers go beyond the boundaries of their creativity at a certain moment and continue to push those boundaries. Imposing the detailed restrictions for the structure and functionality

of an object in their thinking process, they can produce a shape model that they had never imagined. The creation of an idea need not necessarily start from a front view; it can start from a top view, followed by a side view, and then a front view, for example.

Are there any means necessary for expressing a shape in the designers' mind other than hand drawing? The advantage of hand drawing is its unlimited potentials, while creative activities will converge at a stack of numerical values as soon as the tool, CAD, is used.

However, the only similarity between hand drawing and CAD is that there are no manuals for them. There are rules for CAD, while experience and intuition are required in hand drawing. An idea is created by designers and their intention is shared through the use of CAD.

3.3. Hand drawing and doodling

Designers tend to casually draw lines, that is, doodle, on a sheet of paper nearby, particularly when they encounter difficulties in generating an idea. The act of doodling is the process of seeking a "hint" for generating an idea while drawing several lines and cubes with casual strokes of a pencil. When trying to do the same using CAD, we will find that it is impossible to directly reflect our intention on a computer screen on which images are represented by groups of dots and through the use of pointing devices. There is nothing better than the natural impression made by doodling on paper.

A system for converting designers' hand-drawn sketches into 3D shapes has been developed and used by some designers; however, such a system is not yet affordable by everyone.

The necessary abilities in hand drawing are not techniques but the intuition and sensibility to produce a kind of ambiguity. Strictness is not required for doodling, in which we can jot down or draw a flash of inspiration or idea and freely reflect our intention. A blank piece of paper does not tell us anything at all,

and that is why it is the right environment for generating a creative idea.

We are likely to find something new while randomly drawing with a pencil. Moving the pencil, namely, representing what we feel directly on paper following not our head but our heart, will provide a stepping stone for embodying our idea. An idea generated by doodling is gradually developed into a rough sketch. To develop a true design through the process of making a clear sketch using a combination of painting and projection techniques and expanding on the details is the real joy of hand drawing.

4. CULTURE OF HAND DRAWING IN PREPARING DRAWINGS

4.1. Advantages of hand drawing in preparing drawings

Designers make a rough sketch to organize their thoughts during the stage of planning and design of a 3D shape. An effective way of gaining a clearer picture of the idea is to draw a rough illustration on paper. This is the act of turning implicit knowledge into formal knowledge.

The ability to imagine the structure of an object is necessary for understanding an actual 3D shape on the basis of 2D drawings. The interpretation of drawings is required when an object has an unfamiliar shape that we are not used to dealing with. In such a case, pictorial analysis and sketches of each part of the object will provide us with an outline and image of the object. Then, we need not try to memorize all the details of the drawings. The designer's intention is conveyed more concretely by hand-drawn drawings than by written descriptions and conversation. Also, language differs throughout the world, and there are as many languages as the number of countries. On the other hand, drawings are an effective means of sharing information because they appeal to our eyes and do not need to be translated, unlike languages.

4.2. Culture of hand drawing and exchange

of letters

Japanese people who respect good manners have a special affinity for words. Today, e-mail, cellular phones and facsimiles are widespread and have become very convenient means for transmitting information both casually and urgently. However, people used to exchange letters before these advances in communication technology. Characters written by hand with a pen convey the unique attributes of the person who wrote them. Our personality and feelings are seen in the characters we write. The presence of rules for writing letters indicates that letters are written with careful consideration of others.

Communication started from the basic concept of face-to-face contact and has developed into letters, namely, a form of expressing feelings through words that are written and enclosed in an envelope. The exchange of letters is a feature of Japanese culture that we should pass on to future generations.

5. ORIGINALITY CREATED BY INTUITIVE LINES

5.1. Effects of intuitive lines

When we make drawings, a great leap of thinking is required to create a strong impression and a powerful impact. The aesthetics of drawings are expressed in natural sketches. The similarity between drawing in a sketchbook and taking a picture is that they are based on our sensibilities. Namely, they are the acts of seeking beauty and expressing it with our intuition. Our sensibility takes form when we try to figure out complicated matters relying on our intuition. The value of sketches and pictures is generated not by making sketches or taking pictures for a certain purpose, but through the discovery of images and ideas that directly appeal to us moment to moment and recording such images from our own perspective. The images that are worth recording as sketches and pictures are those entering our mind only at that place and time on that day, not at any

other place, time, or day.

These activities are carried out in a natural manner and seem to be accumulated for achieving a certain goal. When the intuitive lines and angles are embodied in the imagined shape or a shape better than we imagined, our personal drawings become popularized drawings and express beauty. This is the start of the embodiment of an idea.

Different from mathematics, there are no definitive answers in drawings. We appreciate drawings in different ways and perceive some consistent impressions that cannot be explained by theories. This is the same as enjoying paintings and music with our eyes and ears according to our desire and feeling at ease with the comfort of not having to fit into any framework. The concepts of framework and constraint are not required for drawings.

Square geometric patterns seem to be more fragile than patterns consisting of curves. It is difficult to draw straight lines and right angles by hand, but hand drawing holds generosity and potential. Images are drawn in a sketchbook and emotional expressions are added to them. The possibilities of an idea will be lost when we construct a shape model on a computer screen from such images. Namely, the unlimited possibilities of an idea are brought out at each stage of sketching, while one idea becomes established when it is processed by CAD. Hand drawing is a necessity for exhibiting our originality that can then be popularized through CAD and embodied.

5.2. Difference in expression between hand drawing and CAD

Humans have reason, five senses, and emotions, all of which are expressed in the lines drawn on a piece of paper with a pencil. Expressing a designer's intention through the compilation of bold lines and delicate painting is a creative activity. Through the repeated process of drawing lines and erasing undesired lines while trying to control even

the angle of the pencil, we ceaselessly combine contradictory elements such as existence and nonexistence and fullness and emptiness, waiting for them to fuse together. In time, the lines start to look different, as if they are alive. A cycle of one idea followed by another will be established at that time. Lines show unlimited possibilities; a line drawn spontaneously will lead to a new line, resulting in a more innovative idea. There is no ultimate image at the beginning. Designers reach an ideal image by reviewing drawings and making modifications to them. On the other hand, neither sensibility nor the vision is required in drawing lines with CAD. The primary role of CAD is to formally convert an idea into a 3D shape model. We select a function of the CAD system and construct a 3D shape model using pointing devices so that the general public can understand the model. With CAD, no light, shadow, or irregular lines are needed. There is no need to express softness or hardness. The significance of CAD lies in the uniformity and the realistic process of expressing a shape necessary for creating an object and specifying the dimensions and tolerances one by one.

It is appropriate to utilize convenient tools for saving time and effort in our daily life, but there is doubt as to whether we can rely on computers for all aspects of manufacturing. Although the concept of design and drawing is the same in hand drawing and CAD, their roles are partly overlapping and partly distinct. Both analog and digital have their own benefits.

6. RELATIONSHIP BETWEEN BASICS OF EDUCATION AND TOOLS

6.1. Basics of education and cause of deterioration of ethics

What we must acquire to live as humans is modesty as well as the skills of reading, writing, and arithmetic, which have enabled Japan to remain a world leader in science and technology while having limited resources.

Japanese people used to receive good education in the home on the basis of the premise that they were not materially affluent. Japan grew into a rich country in a short time, while the consideration of the ethical issues raised by material affluence lagged behind, resulting in the eruption of problems triggered by the arrival of an information-oriented society. Before the arrival of the information-oriented society, people used to learn basic concepts of life and receive ethical education through old picture books or fairy tales, which helped nurture consideration for others.

With the spread of computers, people's attention was shifted from the pages of books to computer screens. Virtual-reality technology has created a world of virtual and imaginary events in which the boundary between the extraordinary experiences in games and the daily experiences in real life becomes blurred. Unfortunately, this is one of the causes of the increase in crimes committed by juveniles who are addicted to the world of virtual reality.

6.2. Decline in thinking abilities caused by dependence on tools

Of man's five senses, the visual and tactile senses in particular are developed through the practice of reading, writing, and arithmetic. For example, we use our fingers (tactile sense) and eyes (visual sense) to move the beads on an abacus. Thinking ability is fostered by the connection between the fingertips and the brain through abacus training, which starts with distinguishing between five-unit counters and one-unit counters, followed by addition, subtraction, multiplication, division, and the basic abacus skills including sums, dictation of sums, and mental calculation.

On the other hand, many people agree that they forget how to write Chinese characters more frequently since becoming dependent on computers. Using a pencil, we write Chinese characters stroke by stroke. Using a computer, we do not have to recall each stroke

of the character because the input is converted into the complete character. Choices of words and Chinese characters are even displayed on the screen, which also diminishes our thinking ability. Similarly, in the preparation of design drawings, we have become dependent on CAD, in which choices are always offered within the framework of drawing techniques. There is a possibility that the negative effects of the dependence on CAD will become apparent in the future. Most universities offer education on design drawings using CAD as a tool, but there is no consensus among them on the content and extent of such education.

6.3. Connection between brain and hands in the use of tools

The German word for tool literally means something generated by hand. According to this definition, tools operate beyond the range of motion of the hands and are created by the hands. Namely, tools are substitutes for and an extension of hands.

A pencil is an excellent tool for us to freely write characters and make drawings merely by holding it with the fingers. This tool can be manipulated at will through the connection between the brain and the hands. Although less expensive than CAD, a pencil is a highly valuable tool.

In ancient Japan, the concept of industrial work was expressed by the word for handicraft. The word for “craft (*koh*)” means “to devise” or “to make something while thinking”. Not only the hands but also the brain is involved in the act of making something while thinking, requiring hand-brain coordination. Actualizing thoughts through the hands gives meaning to “thinking” and fosters thinking ability.

It is therefore natural to assume that hand drawing is helpful to designers who need the ability to draw lines while thinking. Hand drawing enables them to develop their decision-making and thinking abilities for industrial issues through hand-brain

coordination.

6.4. Numbing of visual sense caused by tools

We rarely doubt the characters that are converted by computers, similarly to those printed in newspapers, novels and magazines because, in a sense, they are established.

Similarly, the numbing of our visual sense can be caused by the use of tools such as a numerical control (NC) lathe. A lathe operator can learn “how a material changes with a certain amount of force and what phenomenon is caused by a certain operation” when he manually operates a lathe machine to cut the material while making minor adjustments to the machine. NC lathe operators should recognize the primary roles of lathe machines through such practical experience before they operate NC lathes.

7. CONCLUSIONS

The essence of hand drawing lies in sketching a flash of inspiration or idea on the spot. The greatest advantage of hand drawing is that only a pencil and a sheet of paper are needed to express an idea. Innate talent is not required because hand drawing skills are improved by training. In this paper, I suggested that the dependence on CAD may prevent the improvement of a designer’s ability of graphic expression. Our creativity expands and our ideas are eventually visualized through continuous acts of drawing lines while thinking. The idea expressed by hand drawing has proven to be useful in the process of developing a design.

Is there no need for hand drawing if we have CAD? Is there no need to develop skills in hand drawing in order to use CAD? It is considered that originality will be enhanced if we become accustomed to CAD on a foundation of a full understanding of hand drawing.

Hand drawing of an idea on paper gives clarity to any confusing part and helps us understand the idea more clearly. The act of

thinking while drawing with a pencil stimulates our creativity, enabling us to properly evaluate and analyze the points of an idea and to make adjustments to it.

Hand drawing is necessary to embody an idea, and the primary role of hand drawing is essential for inspiring creativity. The day hand drawing loses its advantages will be the day the significance of creativity itself is called into question.

REFERENCES

- [1] M. Asimov., Introduction to Design, Prentice Hall. (1962)
- [2] Kaoru Hongou., Engineering Design Basis, Maruzen, Co. LTD. (1972)
- [3] Shigeo Hirano, Sozo Sekiguchi., Creative Production Process and Manufacture –From an Idea to Embodiment–, Corona Publishing Co. LTD. (2007)

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