

Chapter 2

Crafts, Children and Computing

Craft is a complex subject, an intersection of makers, materials and methods. It comes with its own cultural baggage, with the perspective of the craftsman herself as well as of those who make up the larger community in which she works. As this study is concerned with the practice of a craft (paper engineering) by children using a software tool, we begin with the uncertainties and difficulties posed by the subject of craft in general, and establishes a framework in which craft learning can be examined in an organized fashion. For instance, craft can be defined in many different ways, and can include many different activities and products. Because of these complexities and multiple perspectives, it is appropriate to limit and organize this subject, and choose a framework for observations of the effect of computation on craft design before proceeding to the more specific area of paper engineering that concerns us.

Craft can be not only be poorly defined, but undervalued. Indeed, in the modern world a person can live quite comfortably without ever owning or using a hand-made object; the value of craft activities and products therefore might not be apparent to many. For many people, the word *craft* carries the connotation of the production of useless items, an activity with which to occupy those who would be otherwise idle, as occupational therapy, or the making of ugly kitsch. Yet, at the same time, the fact is that mankind used to make everything by hand, and a common feeling exists that a handmade object has more value and significance than a mass-produced object. The same person who feels that craft has no place in modern life can also possess the desire to produce something beautiful, unique and useful. Many parents encourage

their children to produce crafts, while expecting them to grow up to be accountants, doctors or lawyers, and not potters or weavers. There is a conflict in the way craft is commonly viewed.

This conflict, viewing craft as both elevating and lowly, is not new. It probably arose as soon as a particular craft was separated from the mass of people, for instance the evolution from the production of pots by everyone for personal use to the village potter. Perhaps it is human to rank order everything, but this partition often placed the craftsman in a higher or lower position in the culture.

...it is by no means certain that early potters were universally respected for their skill...The anthropologist George M. Forster, investigating the status of the potter in a contemporary Mexican village, found that those who practiced the craft both deprecated themselves and were looked down upon by non-potters. "Here you find us in all this dirt," one of his potter-interviewees said to him. [69, pp. 28–29]

Similar stories can be told about other crafts. Blacksmithing was considered a form of magic in early societies, and the smith god exists in many mythologies, as Hephaestus of the Greeks and Ama-tsu-mara in Japan for instance. Blacksmiths can be raised above the general population in status. However, in some cultures, and often for the same reason (that they are considered to practice a form of magic) blacksmiths are outcasts.

The Masai think they bring death and disease. The Wachagga, another African tribe, both fear and venerate them, but think they are particularly undesirable as sons-in-law, since in the case of divorce they are reputed to be able to make their wives sterile. [69, p. 39]

With the coming of the industrial revolution, craft was superseded by machine production for items in everyday use. This caused craft items to become rarer, and valued more for their beauty and uniqueness than for their usefulness. Because of this, however, craft items that are not beautiful or unique (and there are a great many of those produced, as a visit to any craft fair will show) have even less value. The gap between these two notions of craft has grown.

Technology changed both the way in which craft was viewed and its place in society. But technology in one way or another has always influenced craft. In the case of weaving, for instance,

the earliest practice was derived from basket-making, and simply consisted of making mats of fibers without the aid of a loom. The earliest looms, in the neolithic, were probably vertical looms with the threads tied to weights such as stones to keep the correct tension on them. Other types of looms were developed, such as horizontal looms (similar to the vertical loom except for orientation) and backstrap looms, in which the weaver's body keeps tension on the threads. With all of these technologies, weaving is fairly slow, but they can produce better quality fabrics than weaving with no loom [129]. With the development of the floor loom with treadles and harnesses in early China the use of foot treadles freed the weaver's hands, and the speed with which fabric could be produced was much greater. But the introduction of powered looms such as the Jacquard loom in the early 1800s removed the skill of the individual craftsman from the process altogether [90, 69]. Thus it can be seen that the tools used, the technology employed by the craftsman, can change the craft and its products in major ways, even to the extent of converting the craft to an industrial operation. Some technological innovations can aid the craftsman or enhance the craft object. Conversely, some can inhibit the practice of the craft, or make the objects produced more ordinary or less attractive. How can we know what effect will occur? This question is particularly appropriate when proposing another sort of technological change, adding computation to the practice of a craft.

This chapter considers the questions of craft's identity, value, and relationship to computational enhancement. Although this may seem to be a winding detour on the path to the heart of this dissertation, the development of software to help children learn to make their own pop-ups, it is instructive to situate this work in the broader world of crafts and their enhancement. This serves not only to reinforce the value of the craft of paper engineering for children and the difficulties faced in developing software for its practice but also provides guidance when developing the analytic craft framework that will be used throughout this document.

This chapter begins with a definition of craft and its relationship to industry¹ on the one

¹ The word *industry* will be used in the sense of mechanical or factory production of objects, as opposed to simply referring to labor in general.

hand, and to art on the other. With that established, it moves on to examine the value of craft, in particular with respect to children. It then establishes a framework for examining how craft is learned, dividing the subject into three competencies: skill, knowledge, and appreciation. Finally, it uses that framework to look briefly at the ways in which computing can aid or inhibit that learning process.

2.1 What is Craft?

Craft can be described in several ways. The word *craft* is used by members of many professions including writers, teachers, and actors to simply mean *skill* or *practice*, as in *the craft of autobiography* or simply *The Craft*. The word craft is used to describe any skillful means of production, not only of objects, but of activities, such as teaching or music performance.

It is more useful for the purposes of this discussion to begin with another, more limited definition and describe craft first and most importantly as *the production of physical objects*. Limiting the discussion to physical objects, as opposed to activities or virtual objects (those that only exist in the producer's mind or on a computer screen) will simplify and bound this inquiry. This restriction is not intended to indicate that production of activities is not craft, simply that it is not the subject of this investigation. This definition is still very broad, however, and not all object production is craft. However, with this simple definition we have eliminated music, dance, and virtual objects (at least until they are printed or otherwise made material.)

Skill is an integral part of making objects, but craft can occur in the absence of skill. When a beginner produces a craft object, it is still craft, even when the production is not skillful². For this reason, the simple definition does not mention skill as a prerequisite of craft. Although it is not a requirement, skill is still an important component and measure of craft learning and practice as will be shown in Section 2.3.

Of course, not all man-made objects are craft. There are still two important distinctions

² I have a pot made by my daughter when she was in first grade. It does not hold water and is lop-sided but it is still craft.

to be made. First, the term craft is not commonly used for those objects that are made in mass quantities or, more accurately, by machine processes. Second, we do not commonly talk about craft in terms of art objects. That is, most people do not consider fine art to be crafts. But as we shall see, neither of those distinctions are necessarily simple to make.

2.1.1 The Relationship Between Craft and Industry

This definition of craft as *the production of physical objects* is not complete, as we still need to distinguish craft from industrial production. A man-made object may not be a craft object, because it is factory-made and these machine-made objects are not ordinarily thought of as craft. But the dividing line is a fuzzy one. For instance, some pottery is made with traditional methods, but in an assembly-line process, with an electric-powered wheel, and machine tools used to dig the clay. Are these pots craft objects despite the use of several people in production, power tools, or non-traditionally produced raw materials?

We could simply say that *craft is the production of physical objects by hand*, but most, if not all, craftsmen use tools. There are very few instances of crafts without tools; basket-weaving is the only one that comes immediately to mind. The use of hand-tools (hammers, chisels, scissors, etc.) in manufacture does not bar an object from being labeled *craft* in common parlance. But does the use of power tools, a lathe or a computer do so? The line should be drawn somewhere between the factory produced object and the object made without tools. It is important to establish where this line lies in the enhancement of any craft by adding tools, including computation. As was previously noted in the example of weaving, a change in tools can enhance the craft's possibilities (the invention of treadle looms) or destroy the nature of the craft entirely (the introduction of Jacquard looms).

A useful dividing line between craft and industry is the presence of hand-control. This is well-phrased by McCullough: "Continuous control of process is at the heart of tool usage and craft practice. Processes can be indirect, and mechanical and powered, so long as they are under manual guidance." [71, p. 66] The Jacquard loom is an excellent counterexample, as the loom

is under programmable rather than manual control. So the previous definition of craft can be rephrased as *the production of physical objects by manual means*. In this new definition, manual means includes hand tools, power tools guided by hand, and computer methods of design if guided by the user. In addition, many artisans can work on a single object and, so long as each has control in her part of the process, this will be considered craft.

The use of machine-dug clay for pots has been mentioned, and pots made from that clay are commonly considered craft. This definition makes no distinction as to the type of raw materials used in a craft or the method by which those raw materials were produced. Craft encompasses all materials, whether natural or man-made: glass, metal, paper, wood, paint, concrete, and even found objects. Fabric hand-woven from thread that is mechanically spun is still craft. In another example, a basket woven from plastic strips originally used to join soda bottles is no less a craft object than a basket woven from reeds.

2.1.2 The Relationship Between Craft and Art

What is it that distinguishes craft from art? Suppose that plastic strips were used to make a wall hanging, an object with no practical use, as opposed to a basket. Some might say that this is no longer craft, but art. Others would say that the object was only art if it were made from canvas and paint. Choice of material is frequently the key to whether an object is fine art—and sought for the museum wall—or craft—and used on the table. Ceramics, fabric and glass are craft; paint and canvas are art. But what about stone? To many people, in the form of a statue, stone is art, but hollow it out and serve a salad in it and it becomes craft. Paper used for a sketch is art; paper used to make a book is craft. As these examples show, the material employed is seldom useful for this distinction.

The age of the object can be used to make this determination. Here there are difficulties as well. A classical Greek vase is placed in a museum and considered art, but at the time it was made, it was craft. Perhaps all man-made objects might attain this status with passing centuries, but art works can be new as well, and that makes using age alone as a distinguishing trait of art

insufficient.

The difference between art and craft is culturally defined, as well. Originally “there was no distinction between art and craft in Japan, and the terms *bijutsu* (art) and *kogei* (craft) are translations of Western concepts.” [70, p. 398] Even within a culture, the definition changes over time. All of what we consider art was originally craft, and craft can come to be considered art [5]. For example, painting began as decoration in the homes of the rich, as well as public and religious buildings, and was practiced by craftsmen who considered what they did as craft.

Side by side on primitive scaffolding, sculptors, glass artisans, painters, and metalsmiths collaborated to embellish monumental cathedrals...[P]ainting, at the beginning of the Renaissance, was not a particularly status-laden art form...the cost of materials bestowed value on a product, not necessarily the skill with which it was executed. Some patrons even paid for paintings by the square foot. [31, pp. 7–8]

Beginning in the Renaissance, the divorce of jobs requiring the hand from those that were mental and theoretical (and the consideration that the latter were somehow more elevated) began to influence the world of craft, leading to a hierarchy of craft. For example, painting was seen as more refined than sculpting, since painting used tools that were closer to those of the scholar than the mason, and by using color and perspective more closely approached the ideal. Finally the arts were separated from craft altogether, at least in art theory [31]. This separation became more than theoretical over the next centuries [69], that is why many modern cultures still consider artists to be above “mere” craftsmen. (At the same time, there exist commercial artists, who fit more comfortably into the mold of craftsmen, and are considered lower in status for this reason.) Similar changes occurred more recently in photography. Photography was initially considered a mechanical means of recording prosaic images, and later went through several periods of stylistic change just as painting has done, to become an art form for museum walls. Indeed crafts turn into arts and back again frequently, through the process of art absorbing new materials, artists “freezing” their technique into a craft, or craftsmen declaring their status as artists [5].

The case can be made that craft is more uniform in the sense that craftsmen place great

emphasis on following certain technical standards and artists do not, or at least artists attempt to rebel against standards as a matter of course and that "...it might be said that breaking the rules is a driving force for the artist, while following the rules...is important to the craftsman." [84, p. 26] Most craftsmen are concerned with skills and technical excellence; they are focused on workmanship. They are also involved in a tradition, that imposes its own standards on their work.

In their work they are less concerned with design, with the creation of new texts, than they are with technique, with ways of working the stone. Their emphasis is on artistic action, on the process of creation. What matters is the performance of skill. [53, p. 6]

They can be involved in a tradition that imposes its own standards and patterns on their work. "Each craft is the rich repository of many years of practical experimentation and knowledge by men and women whose very lives were shaped and enhanced by the work of their hands." [104, p. 10]

This leads directly to another difference between art and craft. The craftsman is more concerned, on average, with the utility of an object. There is a more practical side to crafts, and in fact one might add the word *useful* to the objects in our definition to distinguish craft from art. "In the crafts, the practical is magical." [87, p. 69] The craftsman celebrates the practical, and if an object is not useful, she might argue that it is not beautiful as well, and in some cases, beauty is not a consideration.

The ordinary craftsman, I think, does not take the criterion of beauty very seriously. Busy satisfying the demands of a variety of jobs and customers, he contents himself that the pipes he installs carry water, that the bookcase he builds is sturdy and fits in the space he measured for it, that the meal is served expeditiously. I have deliberately, of course, chosen examples from crafts in which the idea of beauty seldom enters anyone's calculations... [5, p. 866]

The artist, by contrast, is more concerned with beauty and self-expression, rather than making an object to be used. And Becker [5] distinguishes the *artist-craftsman*, to whom beauty is a major consideration, from the craftsman. Those making stained glass windows, for instance, care as

much for beauty as for keeping out the wind and rain. Using the criterion of utility, our plastic wall-hanging, although made from manufactured material by a traditional craft method, is art. But, considering how many handmade pots sit as decoration, and are never actually used to hold food, this distinction is not always useful either.

The term art is also used to praise objects which would otherwise be considered craft. Craft objects which are particularly skillfully made or beautiful will be called art by those talking about them. This is one aspect of the social value placed on the object and the maker. Craftsmen are paid less for their work, and are considered by Western societies to be lower on the social scale in some respects than artists. This scale has overlaps: an unknown artist might make less than an established craftsman. But she stands a better chance of her work selling for large amounts in the future. This leads to one humorous way to tell the difference: “[a]s far as I can tell there are only two real distinctions to make between arts and crafts. You are allowed to touch and handle crafts before you buy them. Also crafts always cost less than art.” [87, p. 75]

The preceding has shown that no distinctions made between art and craft are serviceable in all times and places. Any differences rely on the intent of the practitioner, the uses to which the object will be put, or the culture or period in which it is made. The differences between craft and art are far more subtle than that between craft and the products of industry. This is particularly true for the domain under consideration in this work. Pop-ups are made from paper, traditionally a fine arts material. They occur in books, and bookmaking is considered a craft. They can be made in a spirit of artistic creation, but are assembled (by hand) in large quantities. Their designers are called *paper engineers* but are often trained as artists. Whether pop-ups are art or craft has no real bearing on this work. For, in fact, “Craft are is replacing art; crafts are art, and perhaps no other art exists.” [87, p. 71]

This work will use the term *craft* to describe the process of pop-up design and construction. There are two primary reasons for this. First, the term helps to distinguish this activity from the curriculum subject of art in schools, although it can be produced there. Second, in the current context there is more concern with the technical workmanship of each item than with the

internal state and purpose of the maker; there is no concern with questions of self-expression vs. usefulness.

2.2 The Value of Craft

One view of craft previously mentioned is that it is of no value in today's society. In part, this is because modern manufacturing has removed much of craft's necessity in everyday life. A new laundry basket, made of plastic, performs the same task as a handmade basket at a fraction of the cost. That handmade basket is now a decorative object, valued for its uniqueness rather than its function. This is compounded by society's propensity to value the skill used in the production of theory, mental constructs, and words on paper more highly than the skill used to produce physical objects. Finally, crafts are often practiced by women and cultural minorities, causing additional devaluation [31].

The world of art (and society in general) often looks down upon the world of craft, as mentioned in Section 2.1.2. Art commonly costs more than craft. The craftsman, simply by calling herself an artist, can gain social acceptance and increase the value of her work. Interestingly, the craftsman can in fact be more skilled than the artist, but make less from the practice of the craft: "crafts are looked down upon because they are associated with manual labor and, thus, with poverty." [87, p. 74]

At the same time, it seems peculiar to be required to defend the value of making objects. After all, tool-use and the making of artifacts are in large part what makes us human. Even in an age when it is not necessary for most of us (in particular knowledge-workers, who are an ever-increasing segment of the workforce) to practice a craft, crafts as hobbies, as well as careers, retain their popularity. Many people practice some sort of craft, and those who do not consider themselves craftsmen can still cook gourmet food, a craft no matter how transient the results, or make their own house repairs even when frugality does not require it.

It is obvious that craft fills a basic human need. Man is a tool-user and builder; craft is pleasurable precisely because it is naturally a part of being human. "You cut and cut and all of

a sudden you see something grow...You feel good inside. You work, it gets brilliant, you see it move. I don't know, it fills you with some kind of emotion—such a sense of satisfaction.” [53, p. 6] The pleasure that most people derive from the practice of crafts and the human history of using tools are possibly the most important values of craft.

It is useful to focus on children's education in order to examine the types of advantages that craft education and practice provide. This work concerns the practice of a craft by children (for the most part, the same benefits exist in craft for adults as well as for children.) It is particularly helpful to examine the opinions of teachers in this regard. Teachers spend time observing children in the act of making objects, and their purpose in having children practice craft is more focused than that of the parents who may be more interested in their children spending time in a manner that is pleasant and safe rather than promoting some particular educational value. In the case of teachers, concrete data exist about their view on the usefulness of crafts to a child's education.

In their study of craft education in England and Japan, Mason, Norihisa and Naoe [70] described how teachers view the value of craft. A sampling of the results are summarized in Table 2.1. This is an interesting summation of the many benefits of craft, some of which are worth a closer examination.

It is important to note that the teachers surveyed were art teachers, and therefore they placed great value on expressiveness. This can be seen in the high rankings for expression and visual skills, knowledge of tools and materials, and aesthetics, all of which are of particular interest to the art teacher. Not surprisingly, items that dealt with self confidence and a sense of achievement received high ratings.

Other reasons that were rated highly do not seem immediately obvious, in particular, the appreciation of cultural heritage and inheritance. Craft often occurs within a tradition and is important as a part of family, regional and national identity. The ceramics of China (the country that gave one form of ceramics its name), the textiles of the Inca, the netsuke of Japan all help define the cultural identity of a place. This gives value to the craft, and to the craftsman. For stone carvers in Italy, the family tradition of stone working means that the craft becomes more

Reason for Valuing Craft	England	Japan
Gives a sense of pride and achievement	98	-
Gives first hand knowledge of tools and materials	95	97
Develops imaginative and expressive skills	96	85
Builds self confidence	95	-
Gives a positive attitude and a sense of achievement	-	95
Helps pupils to appreciate excellence and aesthetic value in crafts	-	92
Develops understanding of relationships between crafts and life	-	92
Develops understanding of the made world	90	-
Fosters visual sensitivity for adult life in the home	89	-
Fosters problem solving skills for adult life in the home	87	-
Fosters problem solving skills for adult life in the workplace	85	-
Fosters visual sensitivity for adult life in the workplace	83	-
Develops understanding of cultural heritage	-	83
Develops understanding of historical, technical and cultural inheritance	78	-
Fosters practical skills for adult life in the home	70	-
Fosters practical skills for adult life in the workplace	69	-
Provides for leisure time pursuits	62	68
Prepares pupils for adult life in the home	-	58
Helps to determine future career choices	57	27
Prepares pupils for adult life in the workplace	-	33

Table 2.1: Data selected and rearranged by decreasing percentage value from a table in [70, p. 405]. The numbers given are a percentage of positive answers for each value. Because of cultural differences, some reasons are different or are not provided for a country.

than simple stonework; it is a matter of identity and pride. As one carver explains:

Everybody when they see on the street the stoneman, they say hello to him, they take off their hat. It was a trade that involved not the mechanical work but involved the art. Everybody knew what kind of working man was that. Some of the old men was so proud of their work. They was so precise. And everybody call him master because he was so good, so meticulous. [53, p. 22]

Tradition also implies a structure of tools, forms, and methods. Working within a tradition, as occurs in most crafts, can be limiting. The tradition imposes a variety of constraints, and requires the craftsman to work within and around these constraints. Thus, the tradition of the craft encourages the fostering of problem-solving and visual skills that have value for children later in life, and were highly rated in the poll described above. The concept of working within constraints

will be elaborated upon in later chapters, as it is an important part of paper engineering, and problem-solving skills will be important in connection with the craft of pop-up making, and its role in various educational settings.

Although the categories in this study appear discrete, there is a significant area of overlap that may not be accurately reflected in the results. For example, although the value of craft in everyday life, particularly in the workplace, does not have a high placement in these results (particularly in Japan), other high ranking categories, such as the understanding of tools and materials and problem solving, would obviously be very useful in everyday life. Even if the workplace is not involved in craft directly, these are worthwhile abilities to acquire. In fact, Eggleston [27] found that making objects in school was actually quite important to success later in life, and that craft graduates were largely employed (not always in their original craft), often in management positions, and often in multi-track careers, that is, in a non-craft career as well as production of craft items separately.

Another study [119] of teachers in both primary and secondary schools in Britain included additional questions about personal qualities that might be fostered by craft. These included such qualities as willingness to experiment, motivation, responsibility, conscientiousness, and honesty. Teachers did not include these values unless asked, but when they were included respondents indicated they were important, although to a lesser extent than practical skills. This also varied by student age:

Teachers have expressed the view that pupils involved in making activities will develop far more than just practical capabilities, although these are seen to be of greatest importance...The research also reveals that the reasons for making activities do differ according to the age of the pupils. Teachers involved with younger pupils more consciously used making...because it enables them to stress the development of personal qualities and attitudes and cognitive abilities. At secondary level making is implicit to the subject and teachers' first concern is subject competence. [119, p. 229]

And finally, not mentioned by the teachers in these studies but obvious to parents with refrigerators covered with children's art, are the objects themselves that can be displayed, given as

gifts, and treasured for a lifetime. Objects inspire children as no immaterial results can, and can serve as social currency when used to interact with others [29].

Thus the practice of craft in schools (and by extension in the home) can be seen to have practical value beyond simple enjoyment. This value comes in many varieties, from employability, to cognitive skills, to creativity and work habits. There are also, of course, related specific skills that can be learned by working in crafts: the mathematics of measuring materials, reading of directions, and so forth, and the production of objects that have value in the eyes of children, as well as their peers and relatives. As with all human activities, the practice and learning of craft is complex, and effects on both the craftsman and society are manifold.

2.3 Learning and Practicing a Craft

In order to study the practice and learning of a craft, and the effect that a change in technology, such as computational design, might have on that craft, it is helpful to break the craft practice into smaller parts that can be more easily assessed. These divisions can be used to build a framework of craft, and in particular craft learning, to allow generalization of the use of computers to learn craft and assessment of the learning of craft. The word *competency* has been chosen to describe each part of craft learning, in order to stress that it embraces a continuum of development, and will change over time.

Many people equate craft with *skill*. It seems logical that the concept of skill should be a part of learning a craft, and that skill is developed by craft practice. But there are certain parts of craft that also involve learning facts apart from skill. For instance, one might understand what a glaze is in connection with pottery, without having any skill or experience in that craft. This cannot be defined as skill, and must be something else: *knowledge*. “In the pure folk definition, a craft consists of a body of knowledge and skill that can be used to produce useful objects.[5]” In addition, there are more subtle areas of craft learning and practice that appear to be different from knowledge or skill. The word *appreciation* is used to encompass these qualities that include the aesthetics, judgments, and traditions of a particular craft and that allow a practitioner to judge

the practice of herself and others. Knowledge, skill, and appreciation are the three competencies used in this framework of craft learning³.

A look at the National Standards for Arts Education [61] provides an example of how these competencies relate to an established assessment protocol. As can be seen in Section 2.1.2, arts and crafts are not naturally distinct; crafts are most commonly practiced in art classes in school, so this seems to be a good place to see what those who teach craft think is important for children in learning crafts. In examining standards for the visual arts there are six content standards defined and they can be seen to directly relate to the three competencies of knowledge, skill, and appreciation:

- (1) Understanding and applying media, techniques, and processes (Knowledge, Skill)
- (2) Using knowledge of structures and functions (Knowledge, Skill)
- (3) Choosing and evaluating a range of subject matter, symbols, and ideas (Knowledge, Appreciation)
- (4) Understanding the visual arts in relation to history and cultures (Knowledge)
- (5) Reflecting upon and assessing the characteristics and merits of their work and the work of others (Appreciation)
- (6) Making connections between visual arts and other disciplines (Knowledge, Appreciation)

The Content Standards can be described in terms of the competencies, and as such these competencies provide a sufficient and, as will be shown, useful framework for the study of craft learning.

A special note here concerns the design and planning of craft projects. This area is often separated from the actual production of objects. In this framework, each of the competencies has

³ The selection of these competencies was largely influenced by my own experiences in learning sewing, weaving, drawing and painting, and various other crafts. It has become apparent over the years that knowledge, in particular the vocabulary of the craft, and the skill of actually producing objects with the craft, were separate parts of the learning process. Appreciation was added later, when I realized that it existed as a separate entity and that knowledge and skill were not sufficient in themselves to cover the practice of a craft.

a relevance to the planning and design of the craft object as well as its construction, especially skill and knowledge. The design of an object is a skill in itself, and involves the knowledge of how such design should be done, as well as the aesthetics of the craft (appreciation). In a similar manner, planning is a skill, informed by the knowledge gained by the practitioner.

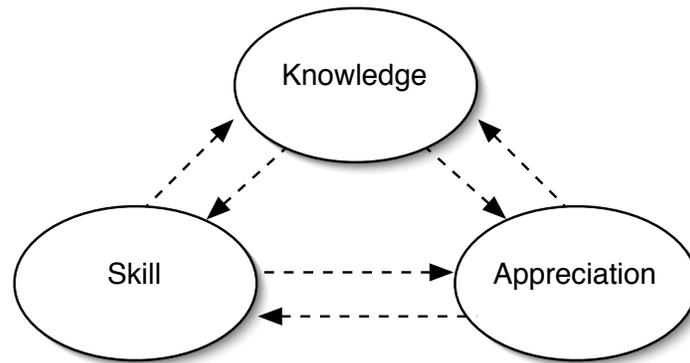


Figure 2.1: A framework of craft learning.

These competencies are not isolated from one another. In order to learn a craft, these are often approached simultaneously. One example is learning in a classroom setting where knowledge about tools or materials may be presented as the learners work to build skill, and where a variety of craft objects may be shown and discussed to build an appreciation of the craft. They also interact with one another, for instance learning a skill will often lead to the appreciation of the practice of that skill in others, and that appreciation might influence the way the craftsman builds her knowledge of the craft.

In validating and clarifying this framework, examples were taken from three craft traditions: Italian stone carving as described by Hunt[53], Southeastern American pottery making told to Hewitt and Sweezy [49] [111], and backstrap loom weaving among the Maya of the Chiapas recorded by Greenfield [40]. These examples are craft traditions, passed on in cultural, regional and family groups where people learn these crafts as a career. Such crafts are well documented by oral historians and anthropologists, and as such provide stories in the words of the craftsmen

themselves. Most of the artisans described learned their craft as children and are therefore better examples, as this work deals primarily with children, than those who learned the craft when older. These craft examples span a range of geographical locations, materials, and cultures, and are also mixed in terms of gender, as weaving is practiced by women, stone carving by men, and pottery by both genders. Since these are general areas of craft learning and practice, they should apply to all learners, whether within a tradition or not.

In the following sections each competency of the framework is discussed in more detail, its selection is explained along with some examples in the sample crafts showing ways it is acquired, its interactions with the other competencies, and ways that it can be assessed.

2.3.1 Knowledge

Knowledge is the competency that is arguably most amenable to study and testing, and probably most familiar to us. It is not by chance that most of the Content Standards listed above relate to knowledge of the craft. Knowledge includes those parts of a craft that can be orally transmitted, passed on in written form, or learned by observation of a craftsman, for example by growing up in a family that practices the craft. Knowledge can be said to be one part of any craft that can be learned without actually practicing the craft. (However, note that some of appreciation has this quality as well. See Section 2.3.3 for more discussion of the relationship of knowledge and appreciation.) Knowledge includes such things as vocabulary, such as tool and process names, and other terms in which the craftsmen talk about their work. Another important piece of craft knowledge is understanding what is possible and not possible given the craft form and includes constraints on aesthetic boundaries as set by the craft community. In addition, craft knowledge can include such things as the history of the craft and what other people have done with it, knowledge of the use and care of tools and the properties of materials, as well as the sort of knowledge of a craft that a good appraiser might possess, such as the value of the resulting object. All of this knowledge can be acquired without actually making a craft object. Knowledge is probably the easiest part of craft to assess, as oral or written tests, or talking with a craftsman

can elicit her level of understanding of the craft.

Something that is frequently mentioned by craftsmen recounting their experiences is that knowledge is often the first step in learning a craft. For example, for stone carvers this can come simply by listening:

I used to hear my father talking about the craft every evening of his life. He would talk about it for hours to my mother, and she was interested in it, too, because all her people were in the trade, and she knew nearly as much as he did. I remember well when I went to work first, how much I already knew about it. I was familiar with all the tools and the terms the men used about stone. [53, p. 21]

or by observing (in this case, watching the master work):

I had to stay right there beside him and look at him. If I was looking somewhere else or doing something else—pomb! I get a little smack on the back of my head. I had to stay there and watch; that was the only way I could learn. [53, p. 21]

Another example of learning through non-verbal instruction is seen with Chiapas weavers. Greenfield notes that young girls are always present when weaving is done, and that “...beginners spend 53 percent of the time observing rather than weaving.” [40, pp. 59–60]

It is obvious that one can know something about a craft without practicing it; the mother of the stone carver quoted above never actually carved. It is also obvious that no craftsman has all of the available information about a craft, its history or its practice in other regions or countries for instance. But even without complete knowledge of a craft, they can still have sufficient knowledge to practice the craft in their own tradition.

As previously stated, none of these competencies stand alone. Knowledge informs both skill and appreciation. In terms of skill, it is often a common practice to watch or listen, then attempt the process to learn the skill. Another example can be seen in the recollections of a potter: “My father had a place in the shop we could slide on under and watch him turn and sometimes he’d say, ‘You make it while I go to dinner.’” [111, p. 99] In the case of appreciation,

one requires some knowledge of the craft to be sensitive to the qualities of an object made within it. As one potter puts it:

The resemblance between the Asian and Catawba Valley pots is kind of intriguing...A thousand years ago fire and smoke and ash rushed through a kiln the same way as it does today. So I can tell by the color of the clay and the glaze on an old Chinese pot, where it was in the kiln and how it was fired. It's like what happens in this community today. Local people can look at my pots and say 'Oh, that one got hot, it must have been up front.' [49, p. 174]

In this case, general knowledge about pottery production can be expanded upon not only by the people in the same region, but applied across traditions in the appreciation of their pots. The knowledge of the physical changes produced by the kiln can be applied to pots made at different times and in different places. Knowledge serves as the foundation on which appreciation is built.

2.3.2 Skill

As previously discussed, to practice a craft knowledge is not enough; it also requires appropriate craft skills. In fact, most definitions of craft involve the word *skill*, and the original meaning of the Old English *craft*, from which the word craft is derived, was skill or strength. All crafts have specific skills including tool selection and use (the ability to select the proper tool and use it correctly in action, beyond the knowledge about tools) and proper handling of appropriate materials.

Skills are acquired by actual practice of the craft. Knowledge about what skills are needed can be imparted by reading or by a mentor, but only actual practice will bring them into being. Admittedly, this is an arbitrary, culture and language-related division. The Mayan language does not make this distinction, for instance, and therefore the weavers of the Chiapas have a different concept of knowledge (*na'* in Tzotzil) that includes both skill and habit:

Na' includes knowledge of the soul or heart; "know" refers to knowledge of the mind. The central meaning of *na'* is knowledge of practice that is both habitual and characteristic of a given person...To say "I know how to weave"

in Tzotzil is to assert far more than skill development; it is to say that I am in the habit of weaving, and weaving is part of my identity [40, p. 52].

For the purposes of the framework being developed, skill is defined as those components of the craft that can only be learned by doing. This is what separates skill from knowledge and appreciation, both of which can be acquired by other means as well. Skill includes not only the more obvious parts of a craft—actually turning a pot on the wheel—but ones that are less obvious. For instance, design and planning of a craft project have a skill component in addition to knowledge about the feasibility and desirability of a particular design. A craftsman can be shown examples of good design and told what things to do in designing a product, but it is only by actually participating in the design process and seeing the results of her own planning that the skill of design, of seeing the result and what has to be done to get there develops:

You have to have the feel—the certain delicate tenderness. All these emotions contribute to a good carver. When you carve something, you have to feel it inside you. You gotta know it's got to be soft here, this has to be sharp, this has to be strong. And this you can't learn. Nobody can teach you that. [53, p. 131]

Even some of the small, and one would think inconsequential, skills of the craftsman become a large part of the practice. For instance, details like taking care of the tools, or cleaning up, are vital, and, while they can be learned (and therefore be part of the knowledge component), they become part of the craftsman's skill set only through practice.

In a woodworking shop, one of the distinctions between somebody who understands working with tools and somebody who does not is to realize that the process of sharpening or sweeping up are absolutely fundamental to the activity of making something. [11, p. 23]

Practice and experience are the defining qualities of skill, and it is only by experience, by actually making objects, that skill is developed. At some point, the learner goes from gaining knowledge to also gaining skill, often through a process of simplification of the skill. Each craft, culture and teacher has a different way of organizing and simplifying the learning of skill to allow

the beginner to experience the craft in a manner that helps to develop skill successfully. Some part of the skill to be learned is taken and presented to the learner, who proceeds to practice. This can be as simple as sweeping up the floor or carrying the finished pots to the shelves, or it can be one part of the process itself. For instance, in stone carving:

And well, you see, in the beginning they give you a piece of rock, and then they make you make a flat surface. That's the first thing you have to learn when you're starting carving. The block is all rough, so you have to make a flat surface—straight, nice, and smooth. Of course, when you know how to carve, you might do it in an hour or two, but when you're beginning, it might take three or four days, you know what I mean.

Another example of simplification of a craft in order to allow the beginner to build skill can be seen in weaving and involves *toy looms*, that are made by or for children from sticks and yarn, in the same style that adult looms are made, with one major design change. In an adult loom, the warp threads (threads that run the length of the material) hold the loom together. In a toy loom, there are extra ropes in addition to the warp threads. This allows the warp to be wound directly on the loom, with the extra ropes holding the loom together as this is done. The adult loom does not have these ropes and requires another device, the warping frame, to be used to wind the warp before it is placed on the loom. By eliminating the use of a warping frame, one step of the weaving process (and a major cognitive hurdle) is removed and the process simplified.

Because threads on a warping frame look so different from the way they will look on a loom, the weaver must mentally transform them to imagine how they should be arranged on the loom...In contrast, this sort of mental transformation is not necessary to set up a play loom...Whereas Zinacatec girls start on the toy loom from about age three, they generally do not set up a real loom before age seven...[40, pp. 47–49]

Skill reveals itself in the action of the craftsman as well as in the finished product. It often requires the eye of another experienced worker in the same craft in order to see skill in action. This is well described in a story one carver told of being tested to join the stone carver's union:

And the president of the union, he was working there, and he came down and gave me a piece of stone, and then he brought me this model, the head

of Christ, and he said, “Can you carve that?”...So I took a chisel and I started roughing it out and he’s watching me. And so after an hour, I’m working, he saw that I knew my business, that I knew how to carve, because you can tell right away, especially a man of his age, his experience, they can tell. [53, p. 33]

Another method of assessing skill is to observe the results of the craftsman’s labor. In this case, the assessment can be made by someone who has developed appreciation, judgment of the craft object (the subject of Section 2.3.3). Once again, having the experience and skill of the craft helps, but skill can also be judged from knowledge and experience of seeing other craft objects of the same type.

Skill helps to develop both knowledge and appreciation. Trying things, whether they work or not, informs the craftsman about what is possible in the craft, and what is not worth trying. It is obvious from the story of the carver testing for the union, that the practice of the skill gives one a sense of what is good in the craft. “All potters have an ‘eye’, a sensibility toward what they make, a dream they make real.” [49, p. 1]

2.3.3 Appreciation

Appreciation is the understanding and enjoyment of the craft results, the tradition and the aesthetics of the particular craft. One does not have to have the skills of the craft to appreciate the results—but appreciation is enhanced in their presence. One does have to have some knowledge of the craft to appreciate in any depth. Appreciation spans a continuum. Saying “Oh that’s pretty” is only the start of appreciation, and requires little or no knowledge or skill in the craft. For the experienced craftsman, there is the ability to look at a craft object and discern methods, tools, and materials used in its construction.

In his discussion of virtuosity as a standard of judgement, Becker [5] describes the relationship of appreciation and craft in general. “But no one can tell whether an object or performance displays virtuosity without learning and accepting the standards of the workers responsible for them.” [5, p. 888] One form of virtuosity is the recognition and development of a style, that

develops as part of skill:

...apprentices...were given the latitude to develop their own styles and techniques of carving, to catch what was best for them, but they also learned that there were “limits of acceptable expression”... what counted was not only inner competence but also the ability to relate that competence to the context that held them. [53, p. 60]

This relationship of competence and context is a key part of appreciation. Craftsmen develop a sense of what is valuable, often within the context of tradition, by watching others work, seeing the objects produced by others, and by practicing the craft themselves. In some cases, the aesthetics of the craft are affected by the business element of craft production⁴. For instance, in stone carving it is necessary not only to make the carving beautiful and in harmony with the tradition, but to produce enough carving to feed a family and the craftsman appreciates the speed with which the work is accomplished:

Thus Vincent began to discover the aesthetic principles that governed the way in which work was performed and evaluated in his grandfather’s shop. The good carver, he came to see, was one who produced quality work with speed, precision, and care; a craftsman who successfully balanced the need to “make more production” with the desire to do “the best first.” [53, p. 58]

The values of a tradition can change over time. The weavers of Chiapas commonly weave different patterns for sale outside the community than those for personal use, and also sell their poorer quality productions. There is a belief that the level of appreciation in those outside their culture is lower, and therefore simpler, rougher ware will pass muster. In addition, their weaving has changed due to greater contact with the outside world, and greater production for outsiders; the aesthetic has changed [40].

When compared to knowledge or skill, appreciation is more difficult to assess. A craftsman would be able to describe the work of others, place it within the context of her own work, and say

⁴ The business aspect of crafts is an important one, and well worth studying, however, it will not be pursued in detail. This is a matter of focus; the concern is with children learning crafts primarily, and the concentration is on other aspects of craft-work. It is not important for this work whether it is made for commercial purposes or purely personal ones.

something about the techniques and skill of the maker, and the value of the work. A craftsman would also be able to compare two works, and perhaps even to make some judgment of a work from another tradition. The ease and accuracy with which this can be done, and the discussion of the specifics of the construction of the assessment object(s) can be used as an assessment of the level of the craftsman's appreciation. Assessment of appreciation requires some level of craft knowledge and appreciation, and, in the best case, skill on the part of the assessor.

Skill and knowledge are necessary for the acquisition of appreciation. In a similar way, the appreciation of the work of others leads to the development of both knowledge and skill. For instance, viewing the work of others allows the experienced craftsman to envision new techniques, new designs, and build up the knowledge of what is possible and what is valuable and attempts to copy appreciated objects lead to the development of new skills or the improvement of old ones.

In the context of the workshop, surrounded by carvers of all levels of skill and ability, they continually watch one another, comparing individual styles and techniques, measuring themselves and evaluating the work of others, striving for the respect and recognition accorded to mastery. "Between ourselves we *knew*," said Roger Morigi, "we recognized the one who was doing very good...And you wanted that, to hear that, and you wanted to be one of them." [53, p. 6]

2.4 Adding the Computing Dimension

In Section 2.1.1, the argument was made that craft can be enhanced by technologies such as power tools and computers, and that if manual control is maintained over the process, it is still craft. This section will examine what can be gained and lost in craft through computer augmentation of the craft process, following the framework introduced in the preceding section to guide the discussion at a high level. This section will explore the possibilities of computer-aided craft-work, and in particular the use of the computer in designing the object to be made.

Adding computation to craft is not a new idea, of course. Computers are now commonly found in sewing and knitting machines, for instance, to allow the craftsman to design and execute complex patterns. Many craftsmen use computer aided drawing programs, the Web to access

pictures of craft objects designed by others, or email to keep in touch with other craftsmen. And there is a plethora of software aimed at specific crafts. At this point in fact, examples of computational craft are too numerous to include them all.

There are also a variety of ways in which computation can be added to craft. The materials that craft objects are made from can themselves be capable of carrying out computation [10, 128, 7]. The tools used to fabricate craft objects or their constituent pieces can be controlled by computers running under control of the craftsman [8]. Computers can also be used for the creation of a “virtual product” (an object that exists only on the computer screen), but as the definition of craft suggests, the product of a craft must be tangible, material and real; this is not augmentation of craft. Computers can be used by the craftsman to design craft objects and to plan for their creation, as in Hypergami [28], that allows children to design polyhedral shapes to produce paper sculpture, and it is this blending that is of particular interest in this work.

Even restricting a discussion to this single augmentation area leaves a vast landscape of topics for exploration, and implies that some bounding strategies are needed to proceed. Two methods will be employed to focus on the core questions around children, craft, and computers. First, the choice of a craft tradition appropriate to children’s abilities will help to assure that the effects of adding computation to the craft will be easier to determine. Second, by applying the framework developed in Section 2.3 to those observed effects, changes that occur in the areas of knowledge, skill, and appreciation can be more readily identified. These choices have also guided the design of the system described in Chapter 5 and the analysis of user studies profiled in Chapter 6.

In this discussion, the main focus is on children learning the craft. Computers can be and are used by experienced, adult craftsmen in their work. Computer-controlled embroidery is produced by many sewing machines today, and milling machines and other fabrication devices are in common use. But there are different considerations for the learner. For instance, efficiency is a major concern for the established craftsman, but too much efficiency can conceal much of what is going on in the process, and make learning more difficult. Much of this is a balancing-act.

It has been seen (in Section 2.3.2) that beginners are often given simple tasks (as with the stone carver), or provided with tools that bypass certain difficult operations (as with the play loom in weaving) in the traditional apprenticeship. This discussion addresses the use of the computer for a similar purpose.

2.4.1 Computer Enhancement of Craft Knowledge

Craft knowledge can be enhanced by applying computers to the design of craft objects in several ways. First, the user can be presented with information about the craft. To some extent, the Web can serve as one such tool⁵. It can introduce the beginner to information about the terms, tools, and techniques of a particular craft in the same way as a book. Computer software that provides help tools, documentation, or labels for its functionality can also introduce the learner to the vocabulary of the craft or provide information about the steps to follow to accomplish some task. By making it easier to design a functional craft item, and harder to design a non-functional one, the computer can build knowledge about how to design. That said, computer learning has the same limitations as learning about a craft by only using books; the learner needs to use those terms with another craftsman to truly learn and understand them. In addition, the helps and documentation may not in fact be used by the learner, even though present.

Notations are used in crafts to guide and record work in progress. For instance in weaving, there are standard notations used for loom set-up to produce particular weave patterns, in counted cross-stitch there are notations for creating a given design, and in architecture there are standard symbols used on blueprints. Sometimes there is no notation, or the craftsman is not aware of the existence of one, and develops it herself. An excellent example of this process can be found in Greenfield [40, p. 160-164], describing the invention of notations for embroidery by the weavers of Chiapas, who had no previous idea of such notations. The computer can present ideas for notations, and in fact can promote the creation of new notations for crafts [47]. Design

⁵ The term Web will be used in this study to mean the “world wide web”, one set of protocols used on the internet.

software requires some form of notation on the screen for the user, and these notations must be developed or adapted by the software designer. The computer can also facilitate the knowledge of notations by presenting both the notational form of the design, and the actual visual appearance of the artifact produced from that design. In weaving, for instance, the finished fabric is hard to visualize from the loom set-up. By showing both representations, the learner can see how they relate to one another, and learn about the notation system.

The computer can present possibilities for design that might not be obvious, or might otherwise be difficult or impossible. The ability to experiment without using valuable materials allows the craftsman to come to some knowledge about design that would be difficult, time-consuming, or impossible to otherwise obtain. Of course, it is possible that this can in fact limit choices and thus the knowledge gained, as the only designs created are those that the computer allows, a subset of those available to the craftsman. The software can hide other knowledge as well. For instance, if the computer uses certain rules to allow only functional designs, but those rules are hidden from the learner, it can be difficult to see what those rules are.

2.4.2 Computer Enhancement of Craft Skill

Computation can enhance skill acquisition, and also hinder it. In order to develop skill, a craftsman must gain experience in using her hands and tools to build. If the computer takes over too much of the work, skill cannot be acquired. If it takes over too little, there might be no advantage in using a computer for the task. It is possible that hands-on experience with the materials and tools will suffer, that only things that the computer supports will be attempted. There can be too much design and not enough fabrication; the learner will spend time gathering knowledge, but less time gaining skill. In addition, it can be possible through computer aid to design things that cannot be made by hand at all. For instance, a computer may be able to design a craft object that is so complex or tiny that it cannot be assembled, or that cannot be fabricated with available materials.

The computer can also promote the development of design skills. The ability to see what

the object will look like can aid the beginning craftsman in the skill of visualizing the object from the design notation. This is something that comes with practice, and there is more opportunity to practice if there are more designs made; the computer can allow more trial designs by making the design process faster. We see once again an advantage of showing not only a notation, but some idea of what the finished product looks like. More opportunity for seeing the finished object before committing time and material to its construction allows more occasions to observe the design process and its alternatives. Augmentation of the design of craft objects can have an effect not only on the skills of design, but on other skills of the craft involved in the actual fabrication of the object itself. For instance, if there is more complexity in the design, more skill must be brought into play to convert the design to reality.

The computer can aid in building skill by serving as a simpler way to design. The computer can function as a device to allow the learner to overcome early difficulties and to be presented with a simplified way to proceed with the craft, much like the toy looms of girls of Chiapas. If this is the case, one test of whether this succeeds is observing that the learner at some point does not need the tool.

2.4.3 Computer Enhancement of Craft Appreciation

Computer enhancement might be thought to be difficult to apply to craft appreciation, since appreciation is largely an aesthetic, a way of viewing the craft that requires the involvement in the craft and contact with its products, often over time. Of course, with enhanced knowledge and skill comes an attendant enhancement in appreciation. And so the discussion about the effects of computer enhancement on skill and knowledge also apply here.

One way that computers can help develop appreciation is by increasing the communication between craftsmen. In the traditional shop, craftsmen are able to compare work and interact. But most people, and especially most children, do not commonly learn a craft in a traditional shop. If they are lucky, they will take a class, where they can observe and trade ideas with teacher and other students. The decline of traditional trade associations and guilds has removed most crafts from

traditional shops and produced many non-traditional practitioners, who is able to only meet other craftsmen at craft fairs [3]. Computers can allow people to trade ideas, designs, and notations over long distances through email or on the Web.

In addition, appreciation can be enhanced through the ability to have contact with a wide variety of craft objects. Using the Web, museums, galleries, and craft shops have placed many examples of crafts for users to study. These examples can take the form not only of photos, but of videos showing the production of objects, and patterns or diagrams showing design. Of course, this is seldom as good as holding the object in one's hand. But it helps to spread ideas and allows users to make comparisons with their own work.

2.5 Summary

Since the rise of industrial production of everyday objects, attitudes about craft have been torn between an idealized view of the craftsman as representative of a lost, better world, and that of craft as useless and cheap. Craft can be defined as *the production of physical objects by manual means* and can be distinguished from manufactured objects by the principle of control. That is, there must be continuous control of the process in making the craft object. The relationship of craft to art is more complex, and it becomes obvious that any distinction is cultural and historical. Art is a form of craft; craft is a form of art.

It is commonly known, in particular by teachers, that craft is a valuable activity for children, and those values include cognitive effects, the development of specialized skills, knowledge of materials, the growth of personal qualities such as patience and responsibility, and the production of objects that have great personal and social value. It has been established that craft is worthwhile as a pursuit for children in many ways.

Since the learning of a craft is a complex human behavior, it is useful to organize it in a way that will allow generalizations to be made about its practice, particularly for the user tests that are part of this study. A framework for craft learning that embraces three competencies, knowledge, skill and appreciation allows for analysis and assessment. Knowledge is the collection

of facts about a given craft, and can be acquired without actually making craft objects, while skill requires actual participation in the craft. Appreciation covers the aesthetic and value judgments that the student learns to make about the craft. All are related, so that they influence one another. For instance, appreciation is frequently based upon knowledge of the craft, and appreciation aids design skills by allowing the craftsman to make value judgments about her designs. These competencies are necessary and sufficient to build a framework of craft learning.

In connection with that framework, and as an exercise in its use, the advantages and limitations of computational enhancement of the design process can be investigated. The advantages arise largely because of the ability of computation to allow more designs to be produced in a given time, the communication available with other craftsmen, the development of new notations and practice with old ones, and the process of simplifying the craft for a learner. The limitations are often caused by the possibility that skill will not be developed if fewer actual objects are created, a stifling of creativity caused by the production of only computer-aided designs, over-simplification of the craft or hiding necessary craft knowledge from the learner.

This discussion continues in Chapter 3, concentrating on the domain of paper engineering, focusing on movable books in general, and more specifically on pop-ups. The analysis of craft in general will be extended to paper engineering and will use the tradition (history) of pop-up making in order to establish the definition of the craft. A discussion of how pop-up making is commonly learned leverages the framework that has been developed. The concerns of the value of pop-up making for children are addressed with a presentation of its uses in education.