Learning Hand To Mouse

CRAIG S. GRIFFEN
Philadelphia College of Textiles and Science

PREMISE

Even more than the Industrial Revolution of the nineteenth century, the Information Revolution that is just beginning will have a tremendous impact on the way we work and think. As we are currently in a transition time between two eras, we are still fumbling with new computer technology to understand how it can best serve our needs. No doubt in a hundred years the technology we think of today as cutting-edge will seem quaint and rather naïve. However it is at moments like these when technological naivete can produce some of our greatest ideas. Leonardo DaVinci lived at another transition time between scientific ignorance and a rebirth of learning. His grasp of technology, though way before his time, was rooted half in myth and half in science. His idea of machines that could fly was not based on scientifically proven facts but rather utilized logical hypotheses derived from observation of natural phenomena. It might have been this attitude, one that refused to stop at the limits of known science but instead utilized a framework of logic, that allowed him to free his imagination to explore new ideas and concepts. Inventors from Victorian times experienced a similar transition phase that produced inventions that ranged from useful to whimsical. By applying new technology of the Industrial Revolution to old forms, they created hybrids that had the seed of a new concept without thoroughly understanding the potential of the technology. (see fig. 1) It seems that these times of transition can benefit from a 'stumbling-through' process providing a platform for future generations to build upon.

I see a similar relationship with architecture and the computer. We are still in the infancy of computer-aided design. Although we have programs that can create incredible graphics and produce documents in a fraction of the time previously required, we are only beginning to utilize the full potential of this technology. At the same time that the computer constantly makes our work simpler and more efficient, there are methods for designing that the computer cannot, and may never, replicate. Specifically, the opportunity for empirical expression as achieved through the use of our hands in the act of making. Although the computer-aided design programming industry is attempting to replicate the way our brains synthesize a multitude of complex information into abstract conceptual thought, I wonder if it will ever fully harness the complexity of the human mind within a computer program. Regardless of whether this happens or not, we need to adapt our design processes during this transition time to create a Frankenstein's monster of sorts that assumes the best qualities of the computer with the timeless talent of the artistic human hand. As this approach is just one version of a 'stumbling through' process on which to base future pedagogical decisions, it can not be regarded as a final destination for a working method. For as computer technology itself changes almost daily, this approach must also be flexible and open to adjustment.

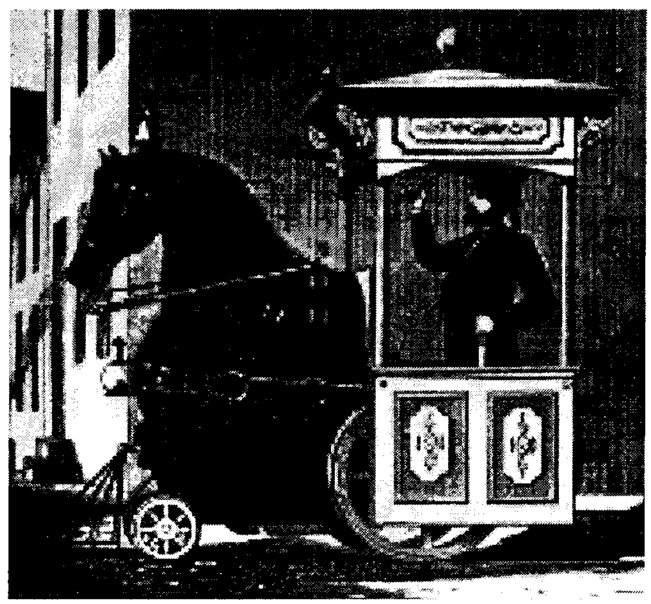

Figure 1.Example of Victorian "Hybrid Invention"

Because this is a very time-sensitive method, I had to make certain assumptions based on the current status of the computer in the profession and the facilities available to our school. Therefore it is on the assumptions below that this current version of a studio working method is based:

1. The computer is firmly established in most professional offices. Some firms do not even provide drawing boards but rely on computer drawings/renderings and physical models. Therefore the student must learn how to design quickly and efficiently with the computer to be competitive.
2. AutoCAD is currently the most widely used program in the profession and the Release 14 version is the main program supported by our school. Therefore the method is specifically geared to the characteristics of Release 14.
3. Programs that allow for total design on the computer starting from the conceptual, schematic phase are not available, affordable or proficient enough and may not be for a while (if ever). Therefore students must learn to make the most of current programs, not just wait for the next new product to come along.
4. There is often not enough time or money available (in the profession or school) to produce elaborate color-rendered computer models of each new design, especially in the early phases. While

wire-frame and shaded three-dimensional drawings can be done rather quickly, highly detailed renderings can not keep up with each rapidly changing idea. Therefore students must learn how to work efficiently with the design tools of a given program to maximize its potential.

The course I teach is a fourth-year studio dedicated to studying how materials and methods of construction inform and direct the design process. During this studio students will focus on how the materials that constitute structure and enclosure systems affect design decisions. Along with these requirements I was asked to integrate the computer into the studio specifically as a means of producing technically precise drawings describing the relationships of the various construction systems. Therefore this meant the students were asked to investigate the potential of CAD in one particular aspect and not as an overall digital design tool. (Many of the students had taken or were concurrently taking a recommended CAD course focusing on construction document production.) With these assumptions and requirements in mind, I needed to develop a method that would extract the best qualities of both computer-aided design and physical making. I first made a list what I thought were the advantages of one media over the other. While neither has total dominance in any particular category, I felt in each category one had a distinct benefit over the other. The two lists below convey the viewpoint from which I based my conclusions.

Advantages of AutoCAD 14 over Physical Sketches/ Models

1. Speed – This is the main advantage to which all the following relate. I apply this to the design process only after the initial schematic design phase in which ideas change too rapidly to make a computer practical. However, once the initial data is entered the ability to manipulate this information via the computer far surpasses hand drawing.
2. Repetition – This includes the ability to copy existing files, reuse and revise existing drawings and text, and utilize standardized libraries and templates (blocks) to greatly reduce design and production time.
3. Formal Experimentation – Complex forms that are too mathematically difficult to describe their construction can intimidate designers. With the computer's ability to calculate complex shapes the designer feels free to create new spatial forms.
4. Layout Flexibility – By drawing in real scale, drawings do not have to be sized from the beginning but can be scaled as necessary during the design process. The function of Paper Space allows one drawing to be reused at various scales and levels of detail without the need for complete redrawing.
5. Numerical Accuracy – While many designers might miss the ability to "fudge" an out-of-scale drawing by just writing in the correct dimension, the snapping function and exact dimensioning greatly reduces the chances for numerical mistakes.

Advantages of Physical Sketches/Models over AutoCAD 14

1. Materiality – By working directly on materials with their hands, designers gain a greater understanding of the haptic qualities of the materials and how external forces act upon them. By building models and constructions they learn about the materials' properties by cutting & shaping them to test their physical capacities. In doing this they learn to let the material inform their design decisions.
2. Stream-of-Consciousness Design – This describes the ability to quickly explore new ideas through hand sketching. Designers are more willing and able to try another idea if it can be quickly and freely expressed in graphic form. This in turn encourages imagination and experimentation. The computers desire for accuracy actually acts as a deterrent to stream-of-consciousness design as each move is a distinct function that needs to be thought out before hand.
3. Depth Perception – The flat screen of a computer monitor can not clearly distinguish between a line that is a section or an elevation. All lines are displayed at the same line weight so although color can help, the constant line thickness often causes students to misunderstand the three-dimensional qualities of what they are representing by those 'colored lines' on the screen. Although computer models begin to address this issue, I believe physical models provide an additional depth perception that helps distinguish between spatial solids and voids.
4. Bodily Experience – The flexibility of the computer to be relatively scale-less (Real scale) and changeable (Zoom functions) on the screen can be detrimental to the understanding of the building's true scale in relation to the human body. By relating the consistent scale of physical models to the designers themselves, students better understand the spatial relationships to the human body and how a person would physically inhabit the space.

PROCEDURE

From these lists I searched for a way to integrate the computer into the design process without losing the empirical experience involved in the act of making. At this point in their education students have had only limited exposure to the materials and assembly details of standard construction. As you must learn to crawl before you can walk, the method I employed first teaches the student about materials from hands-on experience. By receiving information on material properties through empirical learning, students acquire an intuitive knowledge with which to make future decisions. If designers understand the physical properties of the wood, glass, concrete or metal with which they are designing they will more effectively understand relationships between the building systems they will later be representing on a computer screen. Therefore, I structured the course by dividing it into three separate projects revolving around one organizing building program. The projects start predominantly in the empirical, pass through a transition phase and end predominantly in the virtual. To this end the first is a hand-on design-build project, the second straddles both the physical and virtual worlds and the third is primarily computer generated. The studio structure is described below.

SKIN, BONES AND MUSCLE

envelope, frame, and bearing wall

In order to follow development of the student's ability to integrate structural and enclosure systems into design, one building program served as a framework for all three projects. The program subject was the Alexander Calder Foundation; a museum and research center dedicated to the late sculptor in the city of his birth. Calder was chosen as the subject because of the indelible link between the concept and materials of his works. Although best known for his mobiles and stabiles, he was an immensely versatile artist who worked in a variety of mediums and scales including wire sculpture, graphics, jewelry, weavings, wood sculpture and bronzes.

Project 1 – Material Discovery

The goal of this three week project is to teach students about the properties of materials by physically constructing an object at full-size where connections can not be hidden behind a glob of adhesive. The product of this studio is a display unit that would hypothetically be used to hold the smaller works of Calder that would not stand or hang free. Students divide up into groups of three to design and build a freestanding display case to be used in the new museum. Requirements included displaying the object three feet off the floor, protect-

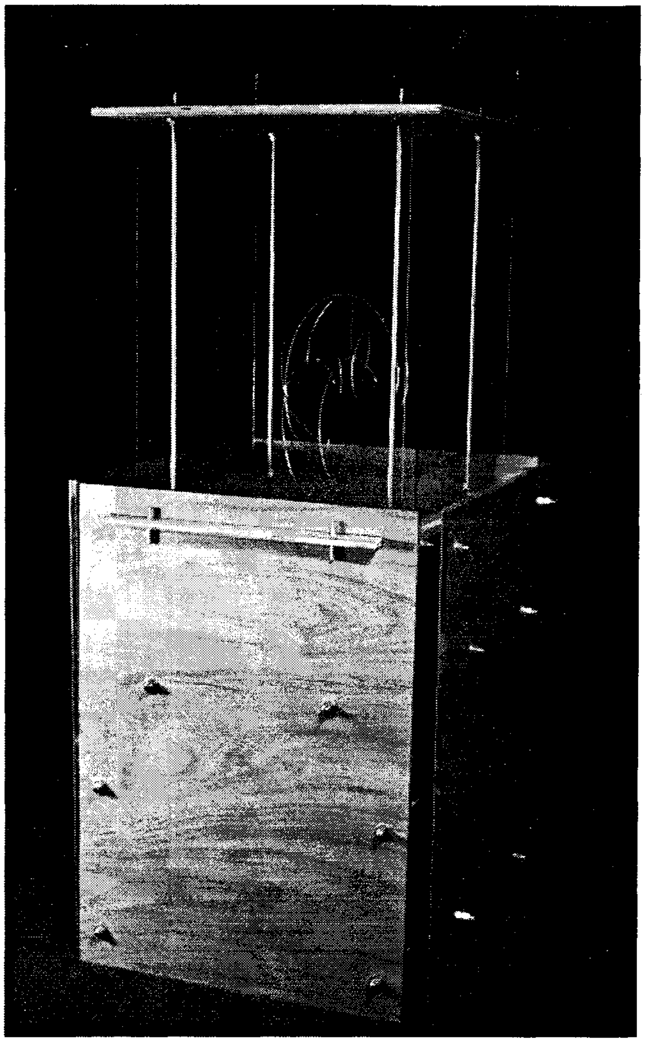

Fig. 2. Display Case by Jason Causton, Jaime Masler & Ben Richards, 1998 (photograph by Jack Carnell)

ing the object behind a transparent enclosure while remaining visible from all sides, using only durable materials and creating a stabile structure. By following these requirements the students are compelled, in effect, to create a small 'building' that provides their first exposure to issues of structure and enclosure systems. (see Fig. 2)

Just making the case structurally stable raises many issues of gravitational and especially lateral loads through either the need for a skeleton frame and/or bearing wall construction. The need to address the issue of supporting the glass or Plexiglas enclosure invited questions of connection details for attaching a delicate skin to a structural framework. While students utilized basic layout drawings to confirm overall dimensions, many of the design decisions were made during construction, overcoming limitations by adapting available hardware and materials to meet their design intentions. Properties of the materials dictated many of the design decisions. For example, teams who chose glass for their enclosure could not afford to have it professionally drilled so needed to devise their own unique clamping details to hold it in place. All of the projects utilized some form of metal so for most of the students it was their first hands-on experience with cutting, drilling and welding steel or aluminum. (see Fig. 3) The empirical knowledge about the properties of metal gained by physically working with it can not be matched by representational means. For inspiration the students were asked to capture the spirit of Calder's work by studying the way he utilized the best properties of his materials without mimicking his forms. By having a theoretical base from the start, students could observe the process by which a design concept can be carried through to the most intimate details of construction.

By the end of this project, students should have developed an understanding of the relationship between representational drawings and the final product. They get to see an object progress from initial conceptual design to final built construction, an experience that does not happen often in school with a building design. Through this experience they learn how an initial concept can change over time as the various issues of real construction influence and affect revisions in the design.

Fig. 3. Display Case by Wayne Broadfield, Mark Marshall & Jesse McCarter (photograph by Jack Carnell)

Project 2 – Building Design

This is the main design project of the semester and lasts for eight weeks. During this phase the hybrid method of working both by hand and by computer is accomplished. This project is the one most similar to a typical studio design exercise where a comprehensive building design is the final product. However it does differ in the process by which students progress through the design. To utilize the best qualities of both hands-on construction and computer modeling the student is given a series of deadlines for required products that alternate between hand-made sketches/models and computer generated drawings. It is likely the student will never use a parallel rule the entire semester. After their initial site and program analysis, students start by synthesizing the resulting information in the form of hand sketches. I believe AutoCAD cannot provide the artistic freedom required for stream-of-consciousness design that comes with a freely flowing "big pencil" on trace. These sketches, as well as quick study models, help the student freely experiment with multiple often divergent ideas to discover their design concept. After the parti has been firmly established, students develop a series of computer "sketches". These are intended to be quick, unrefined drawings created by "throwing" lines and solids on the screen representing some of the given and student-imposed influences on the design.(see Fig. 4)

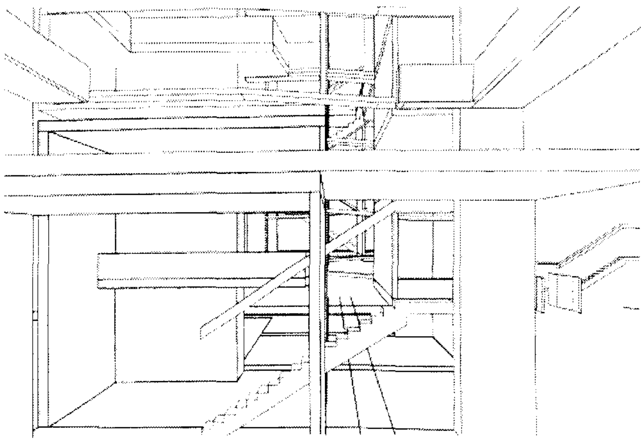

Fig. 4. Computer "Sketch" by Jason Causton

After the design has reached a certain level of actuality, these computer drawings will serve as actual templates for constructing physical models. Too often models present only an external image of a building that does not reveal the spaces inside which should be the student's main focus. However, with templates students can quickly plot the latest variations of floor plans and elevations, mount them to boards and assemble them in three dimensions. Any necessary changes can be quickly revised and reprinted to study another version. These study models reveal spatial issues not evident on the screen or from massing models. (see Fig. 5)

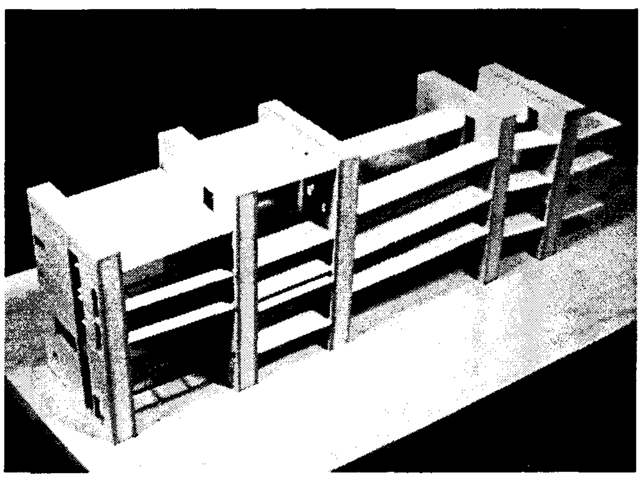

Fig. 5. Study Model by Jason Causton (photograph by author)

This alternating movement between physical models and computer drawings continues for the rest of the project with each phase becoming more refined. To help increase the complexity of the design, students spend a week each analyzing structure and envelope to observe how they inform and direct the design. They are shown examples of existing buildings in which either the structure or envelope or both are a driving idea behind the design. They then incorporate their own ideas into their models and drawings. The final products for this project are a physical model revealing the basic structure and envelope systems (and by default, the spatial conditions) and a complete set of computer generated drawings of their design. (see Fig. 6) By alternating back and forth between the two media, students use the speed of the computer to quickly produce, copy and revise drawings that can be utilized to construct tangible models revealing complex spatial conditions.

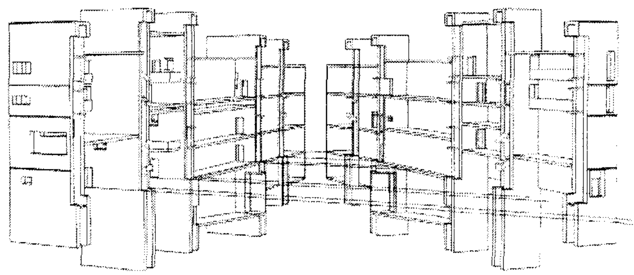

Fig. 6. Computer Drawing by Jason Causton

Project 3 – Computer Documentation

For the final three-week long project, students carry their conceptual design intentions to their structural and envelope systems and learn how to clearly represent and depict them in the twodimensional media of computer-generated drawings. As the drawing is the medium by which an architect describes to the builder how he intends the building to be constructed, students must learn how to clearly communicate their three-dimensional ideas in this two-dimensional format. During this phase they will select a section of their building where the details are critical to fulfillment of the design concept and develop it at a larger scale. Typically this will be a wall section that depicts an important relation between structure and envelope. Using only the computer the student will develop the section, along with its related elevation and plan, by selecting specific materials and creating assembly details. After this is accomplished, a compositional drawing is created that integrates the section with the most critical design drawings into one all-encompassing layout to thoroughly describe the structure and envelope at several scales. (see Fig. 7)

his drawing takes advantage of the computer's ability to copy and reuse the existing plans, sections, elevations, etc. that were produced in the previous project to manipulate them in scale and embellish them in detail. Students also take advantage of the AutoCAD's flexibility to use the Paper Space function to layer drawings of different scales but similar concept and integrate them by an appropriate graphic technique. Overall dimensions and material symbols and notes are added to accurately describe the technical intentions of the design without need of verbal elaboration. This drawing becomes a comprehensive summary of the tectonic systems in one technically precise document utilizing some of the best features of the AutoCAD program.

CONCLUSION

By the end of the semester students have investigated materials, structure and envelope from the very physical world of hands-on construction to the virtual world of computer representation. It was encouraging to see many of the connection details that were developed in the first project carry through to reemerge in a similar form in the final project. Before the studio most students addressed the materiality of their designs with general and vague descriptions.

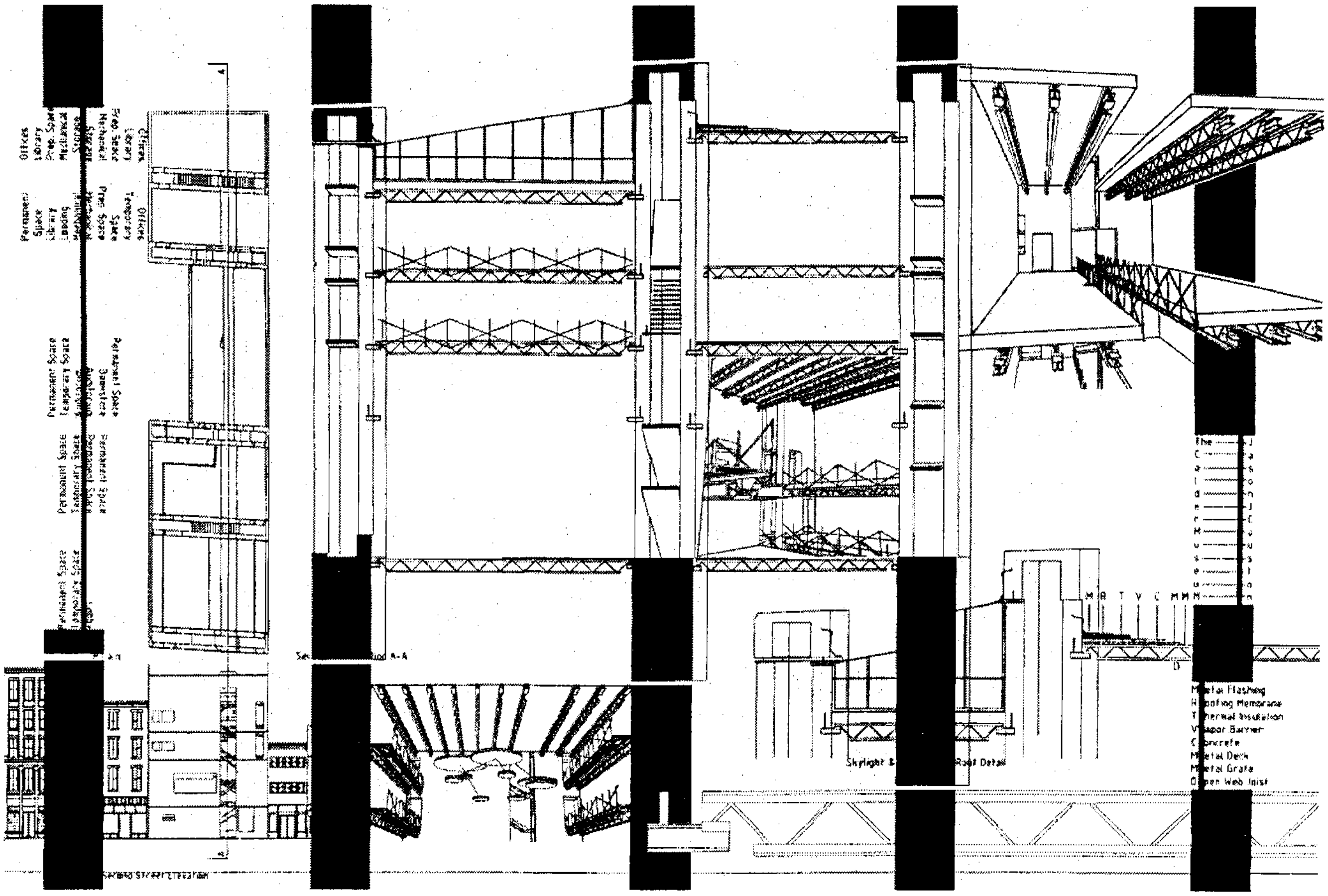

Fig. 7. Compositional Drawing by Jason Causton

Structures they initially conceived of as 'metal beams and columns' were later understood as 'steel angle trusses welded to wide-flange columns.' Transparent enclosures initially described as 'glass walls' by the end were recognized as 'aluminum and glass storefront and curtain walls systems.' Students were able to take the materials out of the abstract realm and understand them as real, physical things that are combined into integrated assemblies. They further learned importance of clearly representing these details in the format of computer-generated technical drawings.

While the students often were able to exceed my expectations of their knowledge of the computer's capabilities, they were still hesitant to use it in an unimpeded manner as evidenced by the computer "sketches" being rather controlled and defined. They still seem to consider even basic CAD drawings as more "finished" than hand sketches and were reluctant to substantially alter them. While this method is already out-of-date and would require revisions to be used again, (the Architectural Desktop program now available addresses some of the concerns with Release 14, especially in the transition from schematic design to construction documents) I believe the basic procedure can work as well or better with all CAD programs. The important issue is to develop the student's intuitive sense of physical construction as a platform from which to expand their knowledge of the virtual world. No matter how far CAD technology develops, we will always remain sensory-based human beings. With this as a base of reference, students will have the ability to integrate the computer as a valuable tool in their design process regardless of where technology takes us in the future.

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