

# WEB-BASED VISUALIZATION: AN INNOVATIVE APPROACH TO PROVIDING TECHNICAL INSTRUCTION

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## Abstract

*For some time, computer graphics and illustrations have been used to convey information between customers and suppliers and between teachers and students. Procedures and tools used to convey information have dramatically changed. However, one idea has not: Graphical information can be interpreted more quickly and more accurately than information transmitted through written or spoken language.*

*Today, there is an increasing demand for visualization tools in both manufacturing and education. Visualization is presently used to clarify or convey ideas, to overcome language barriers, to enable information to be swiftly processed, and to storyboard process change. Visualization proves to be an invaluable tool in every facet of the manufacturing process. In industry, graphical information is utilized in the areas of product design and development, facilities design, and in the marketing of manufactured goods. Visualization is important for process improvement, providing workplace instructions, and to ensure safety. In traditional education, approaches to visualization have included text illustrations, films, overheads, chalk-board sketches, and physical prototypes; two primary limitations with these visualization approaches have been interactiveness and/or accessibility.*

*In some engineering and technology-related programs, the use of visualization in a web-based environment has the potential for bringing workforce practices to students. More importantly, web-based environments allow visualizations to be interactive, and a variety of concepts can be taught over any distance. Technical instruction does not have to be purely facilitative; instruction can be effectively designed to be interactive and to provide students with control over their learning process. Effective web-based instruction involves a synthesis of cognitive theory, instructional technology, understanding student needs, and understanding the distance education technology available.*

*Unfortunately, with web-enhanced technical education, educators often struggle with learning effective Instructional Technology practices, with different educational philosophies, and in the selection of necessary tools for reaching educational objectives. The creation of complex geometric virtual prototypes, the production of videos, or the development of web-sites are often viewed as daunting tasks. With a web-based generation of learners, expectations involving visual learning are extremely high. However, there are many easy and effective approaches to using web-based visualization in the design and development of technical curriculum and instruction.*

## Visualization

“You can see more information in a second than you can hear in a day” (Hayhurst, 2004, p. 50). “Visuals give added meaning to words” (Newby et al., 2000, p. 100). A picture is worth a thousand words... Statements such as these can be backed by applications common in our world today. Even prominent intellectuals of the past have expressed the importance of visualization. Lockhart & Johnson (2000) quote from the writings of Albert Einstein:

*The words or the language, as they are written or spoken, do not seem to play any role in my mechanism of thought. The physical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be ‘voluntarily’ reproduced and combined – this combinatory play seems to be the essential feature in productive thought before there is any connection with logical construction in words or other kinds of signs which can be communicated to others. (p. 54)*

Visualization is seen as the primary vehicle used to convert massive amounts of data into easily discernable shapes and colors, and for envisioning things that are too small or big, or that are too far away or simply out of sight. In the design process, visualization allows for exchanging information between the different stages required to transform a concept into reality (Firebaugh, 1993; Lockhart & Johnson, 2000). Whether there is an interest in designing a part, learning a new surgical procedure, or simulating planetary systems, computer graphics allow us to see and understand more clearly than by any other technique. Figure 1 illustrates a web-based application, Microsoft Terraserver, used to deliver topographical or aerial photo information to the user. With this, the user can visualize places within the United States that normally would not be as accessible.

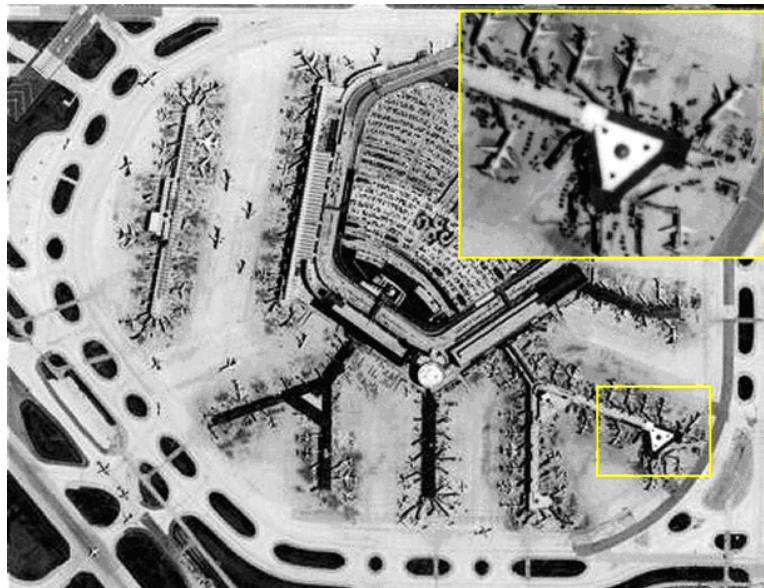


Figure 1. Web-Based Aerial Photo of Chicago O’Hare Airport  
([www.microsoft-terraserver.com](http://www.microsoft-terraserver.com))

Visualization often involves the enhancement of three-dimensional perception, color, and patterns through the application of a computer-supported system. According to Schroeder, Martin, and Lorensen (1998), visualization is “the transformation of data or information into pictures” (p. 1). By definition, visualization is “1: formation of mental visual images 2: the act or process of interpreting in visual terms or of putting into visual form” (“Websters, 1989, p. 1319). There are dozens of other related definitions of visualization on the Internet.

Schroeder, Martin, and Lorensen (1998) explain the importance of visualization brought about through computer technology:

With the introduction of computers and the ability to generate enormous amounts of data, visualization offers the technology to make the best use of our highly developed visual senses. Certainly other technologies such as statistical analysis, artificial intelligence, mathematical filtering, and sampling theory will play a role in large-scale data processing. However, because visualization directly engages the vision system and human brain, it remains an unequalled technology for understanding and communicating data. (p. 4)

Virtual reality, real-time animation, image processing, virtual prototyping, and engineering analysis post-processing, extend the capabilities of Computer-Aided Design. Other visualization tools such as panoramas, digital photos, and videos are seen as a means to bring an environment to the user. Many of these are supported by the World Wide Web. Not only can images relay information over a distance in almost any discipline, but visualizations can be profoundly enhanced with the interactive capabilities hypermedia has to offer. How visualizations are used is just as important as what visualizations are used.

Internet technology has changed the way global business is conducted and the ways information is shared. In an effort to meet changing expectations, to respond to market trends, to simplify product development, or to educate, visualization capability supported by the World Wide Web, offers significant opportunities. Not only does the World Wide Web allow information to be easily shared, applications with interactive capabilities are also supported.

### Visualization in Education and Industry

The primary purpose for using visualization has not changed significantly in the last few decades. Within instruction, Dwyer (1972) describes visualization as a means to clarify and compress information, and to punctuate or emphasize a particular point. Dwyer explains:

Visualization is said to:

1. Facilitate the accuracy and standardization of the message being communicated;
2. Bring into the classroom inaccessible processes, events, situations, materials, and phase changes in either space or time;
3. Illustrate, clarify, and reinforce oral and printed communication, quantitative relationships, specific details, abstract concepts, and spatial relationships;
4. Provide concreteness (realistic detail) in the learning situation;
5. Increase student interest, curiosity, and concentration;

6. Present the learner the opportunity to perceive an object, process, or situation from a variety of vantage points;
7. Provide important instructional feedback (Dwyer, 1972, p. 1)

These seven points are the basis to justify the use of visualization in education today. Newby et al. (2000) explain that visuals can appeal by attracting attention, provide real examples, stimulate thought or inquiry, increase processing efficiency, improve comprehension and memory, and illustrate procedures. Lockhart and Johnson (1999) claim that visualization tools are necessary for communicating design features and ideas and that using images helps conceptualize.

Studies indicate that audio-supported images and video can benefit instruction. Swan's (1996) studies of sixty-seven college students found that video incorporated into hypermedia instruction enhances learning. Swan's conclusion suggests that video added to hypermedia promotes meaningful learning, improves retention, and provide more links to existing knowledge over students who did not have access to video. Another study conducted on college students by Beauchamp & Braden (1989) (as cited in Braden, 1996) led to the following conclusions:

1. In a sight-plus-sound presentation, when verbal language is used to appeal to only one sense via either printed or spoken words, cognitive achievement is not significantly diminished.
2. Pictures used in a sight-plus-sound presentation prompt viewer recall from memory or experience of information not in the presentation.
3. Cognitive stimuli prompt immediate cognitive recall.
4. Visuals, especially photographs, prompt immediate positive affective responses to a presentation.
5. Music from a sight-plus-sound presentation, more so than visuals, prompts long-range, or delayed, positive affective responses.
6. Students are aware of "when" and "if" they are learning. Changing the delivery-of-instruction mode does not change this apparently innate sense of learning.
7. A desired change in attitude is prompted through the introduction of new concepts and ideas, not through the presentation itself. (p. 503)

Within instruction, especially student-centered learning, the authors have found similar results to these. Students tend to be more attentive, interested, and motivated when visualizations are supported by other communication mediums.

Industry relies on visualization to convey designs, control practices, inform, train, and sell ideas. Hallett (2001) explains that web-based visualization tools can provide company decision-makers with real-time reports, 3D graphics, and multi-panel views that categorize, organize, and distribute a vast amount of information that can be quickly processed and better understood in making informed decisions. Visualization plays an integral role in digital prototyping, simulation, training, and finite element analysis (Schroeder, Martin, and Lorensen, 1998). Advantages of web-based visualization include access to real-time information while overcoming geographical constraints, in a manner that non-technical users can understand (Hallett, 2001). Schroeder, Martin, and Lorensen (1998) explain how the weather patterns we

often see are scanned and digitized data that is modeled by supercomputers to form understandable visualizations. Figure 2 shows a web-based application of these complex systems that people routinely interpret.

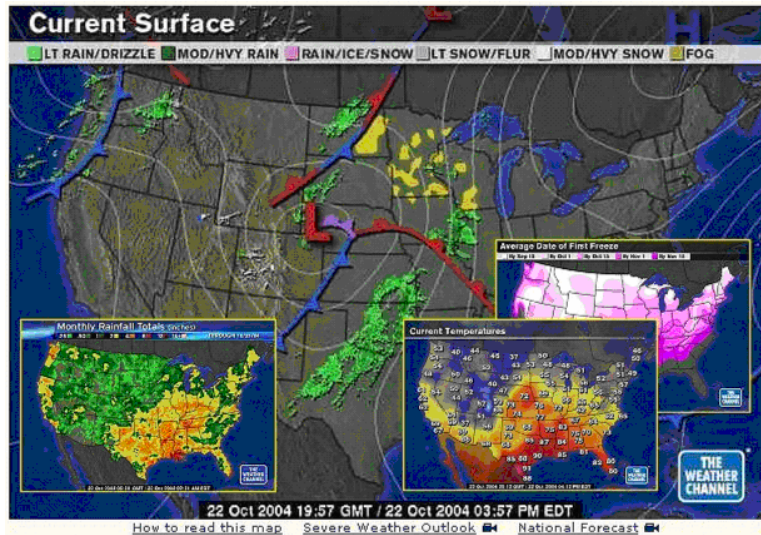


Figure 2. Web-Based Weather Map (www.weather.com)

Visualization has been important for companies in the control of production operations, an essential requirement for process standardization and eliminating non-value-added (wasteful) practices. Figure 3 shows two examples of work instructions on shop floors at two different companies. Photos have been integrated into the work instructions to assist in rapid training or to process information quicker and to overcome literacy issues. Notice how the company at the left in Figure 3 places the visualizations where work occurs to minimize time spent looking at instructions somewhere else.

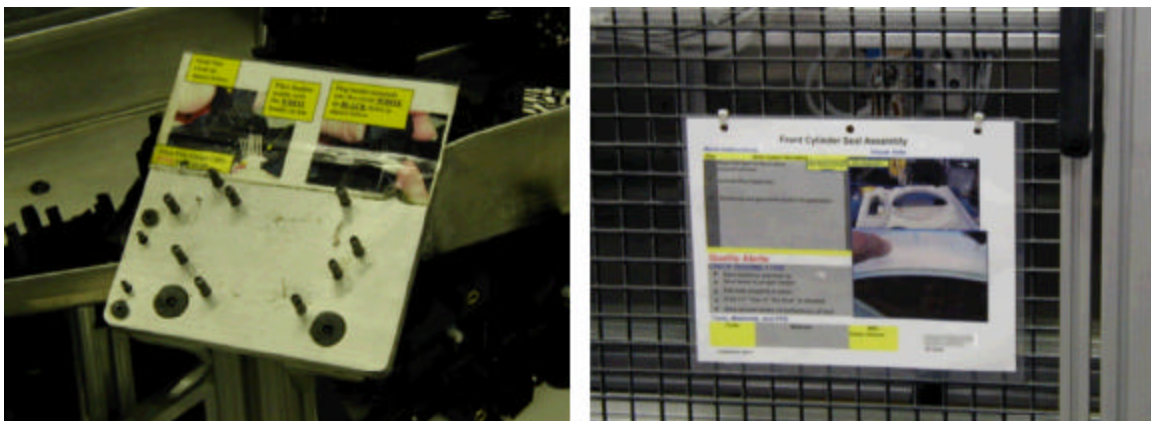


Figure 3. Visualization for Work Instructions

Some companies have taken visualization to new levels, realizing that using computer terminals and the Internet can efficiently deliver work instructions or share production data to shop floor

personnel. Motorola, one such company, used digital pictures to deliver work instructions for assembly, testing, and packing to factory-floor workers via computer terminals and an intranet (Cronin, 1997). This ability has helped employees become better informed; if there are problems, highlights or notes can be passed down to employees instantly.

### Visualization Approaches

There are several visualization approaches, each having advantages and disadvantages. Advantages of some approaches over others include interactivity, realism, three-dimensional information, ease of generation, and no size constraints. On the other hand, some visualization approaches are limited because they lack realism, cannot be shared over the Internet, or lack interactivity. Traditional visualization approaches are compared in Table 1.

Flat Drawings	Photographs	Animation	Video	Virtual Models	Physical Prototypes
Do not convey realism	Convey Realism	May or may not convey realism	Convey Realism	May or may not convey realism	May or may not convey realism
2D information	2D information – limited 3D	2D and 3D information	2D and 3D information	3D information	3D information
Non-Interactive	Typically non-Interactive / can be interactive using hotspots	Non-Interactive	Typically non-Interactive / can be interactive using hotspots	Interactive in real-time	Interactive in real-time
Ideas conveyed over any distance through multimedia	Ideas conveyed over any distance through multimedia	Ideas conveyed over any distance through multimedia	Ideas conveyed over any distance through multimedia	Ideas conveyed over any distance through multimedia	Ideas limited to localized area
Creation / Modification through software	Modification through software	Development / Modification through software	Modification through software	Development / Modification through software	May be difficult to manufacture / modify
Virtually no size limitations	Virtually no size limitations	Virtually no size limitations	Virtually no size limitations	Virtually no size limitations	Size limitations
Do not accurately depict color, shading, or reflectivity	Accurately depict color, shading, and reflectivity	May/May not accurately depict color, shading, and reflectivity	Accurately depict color, shading, and reflectivity	May/May not accurately depict color, shading, and reflectivity	May/May not accurately depict color, shading, and reflectivity
Extensive time to generate	Little generation time	Extensive time to generate	Little generation time	May require extensive time to generate	Extensive time to generate

**Table 1.** Comparison of Traditional Visualization Approaches

According to Coyle and Thorson (2001), “One of the most important dimensions that differentiate new media from traditional media is the level of realism provided. New media can incorporate levels of vividness and interactivity that traditional media cannot” (p. 65). Flat drawings provide information in the form of instructions. These can be for students, construction workers, or factory employees. Although there are several methods to create them, flat drawings by themselves lack realism and are limited to two dimensions. Photographs convey realism, but lack interactivity by themselves and are limited to two dimensions. Animation is well suited to provide more detail than still images, but may lack realism and certainly lacks interaction. Video provides realism, but by itself, lacks interactivity. Virtual models allow for interactivity and detail, but may or may not convey realism. Physical prototypes convey realism and allow for interactivity, but ideas are limited to a localized area. As you can see, in most cases, visualization

approaches by themselves lack in one way or another. Many of these approaches however can become more powerful when coupled with scripting languages and when delivered via the Internet.

### Learning Theory, Hypermedia, and Visualization

DeMiranda & Folkestad (2000) explain that the design of technical instruction should be such that students acquire and apply cognitive and meta-cognitive strategies for using, organizing, managing and discovering knowledge; students should be active and engaged in “learning-by-doing” activities. “Whatever delivery medium you work with, awareness of the variety of learning styles which your learners may possess can help you make effective decisions about your presentation of information, the guidance and practice you provide, and the kinds of assessment you offer in instruction which you design” (Keirns, 1999, p. 147). Buckley, et al. (1999) describe how higher education is shifting from a Teaching Paradigm to a Learning (Active Learning) Paradigm. Recognition of differing learning styles and learner experiences are two driving forces for this shift. Buckley, et al. (1999) demonstrated how interactive multimedia learning environments were designed at the University of Hartford to assist students in the learning of facts, building concepts, experiencing critical inquiry, and to foster student-originated research. They found that learning outcomes were improved and content that was previously challenging to teach was made possible through technology. Todd (1990) writes, “It is more important for teachers to be expert in the learning process; they must be experts in the process on how to help others go about learning” (p. 6-7).

Wilson & Meyers (2000), Fraser (1999), and Dwyer (1972) explain that learning takes place in a context and that cognition is tied to action within that context; they emphasize the importance of interaction with the object or situation for learning to occur. However, interaction is not always possible due to a lack of accessibility (Dwyer, 1972). This holds true today for engineering and technology-related fields. Students may not have immediate access to manufacturing industries to witness practices due to time constraints, location, corporate policies, safety concerns, or educational budget constraints. “In order to alleviate the need for concrete personal experience and to facilitate learning, visual illustrations have been used to compliment oral and verbal instruction” (Dwyer, 1972, p. 3). The use of visualization is seen as a way to shape context and provide learning opportunities to students.

It is widely accepted that graphical information can be interpreted more quickly and accurately than information transmitted through written or spoken language, and the World Wide Web is seen as an effective medium for overcoming distance and time related issues. Despite this, Fraser (1999) explains that most web publishers have adopted “shovelware”, a practice where content is shoveled from one communication medium to another without any regards for the capabilities of the second medium, ease of use, or appearance; information is simply converted. Fraser charges that educators distribute syllabi, assignments, notes, references, etc. on the web, and almost all of what is out there is *shovelware* having no pedagogical value whatsoever. Much of the *shovelware* that is created not only has pedagogical lackings, but also fails to make use of visualizations other than text.



Hypermedia, or network representation of information, offers several advantages including presenting information in a non-linear format, allowing users to freely choose the information they wish to inquire, viewing information from different perspectives, and promoting interaction (Uden, 2002). Hyperwebs, as Breck (2001) describes them, better reflect the way we think; information can be explored in a non-linear way. Rada (1995) writes, “With hypermedia the user can point to a portion of a video and change the direction of the video” (p. 164). In fact, the designer can have several hotspots (or buttons) on a particular scene for the desired time. These can activate links to other scenes, web pages, audio, other videos, and an endless number of options. With these abilities, instructional designers can develop interactive performance exercises that can challenge the learner.

### Visualization and Interactivity

By definition, interaction is a “mutual or reciprocal action or influence” (“Webster’s”, 1989). In the traditional sense of the word, interactivity refers to control and/or manipulation of objects and space. Barker and Giller (2002) explain, “Typically, interactivity is used: to facilitate navigation through the corpus of materials that make up the product; to provide assessment and feedback mechanisms; and to facilitate communication between the group of users that constitute the ‘learning community’ at which the product is focused” (p. 2). Providing interactive opportunities is always problem in education, either because of resources required or resources not available. Usually laboratories are seen as the principal method for fostering interactivity. As all educators know, laboratories require equipment, constant maintenance, and upgrading. Instructional designers recognize that physical laboratories are not the only method for fostering an interactive environment. Hallet (2001) writes, “Flexible, web-based tools allow decision-makers to interact with data. New Java-based visualization tools allow decision-makers to interact with the graphic representation. This feature can be invaluable for decision-makers interested in exploring specific business scenarios or digging deeper into a specific business issue” (para. 14). This also applies to technical education.

Hemphill (2000) describes four levels of interactivity. These are from the lowest level to the highest level:

1. Explanation: presenting or facilitating of information on a screen – no thought or learner recall involved
2. Tips: allowing the learner to make choices and providing pop-ups with choices, but not requiring a response or recall of information
3. Inquiry: prompting the learner to respond to a question, but not requiring a demonstration of learners recognition or understanding
4. Simulation: a practice activity in which the learner demonstrates new skills and responds to information

The level of interactivity is shaped by visualization approaches, and visualization approaches can determine pedagogical value in instruction. With traditional approaches, visualization has been used to deliver or facilitate. Physical photographs convey visual information, yet lack the ability to be conveyed over a distance short of copy and distribution methods; they also lack any real interactivity; they cannot provide additional text or visual support or direction to the viewer.



Digital photographs convey information over any distance, yet these also lack any interactivity. Now, with the use of hypermedia software, visualization has the ability to become interactive. For instance, digital photographs with applied hotspots and layers in a hypermedia format not only convey information over a distance, but they allow for designed interactivity. Interactivity may be in the form of information retrieval, such as audio support, text support, links other visual information, or manipulation of models in a virtual environment. Interactivity also supports assessment and most importantly, practice opportunities. This capability has the potential of changing instruction in all disciplines. Figure 4 illustrates how the methods used to construct and share visual information have evolved.

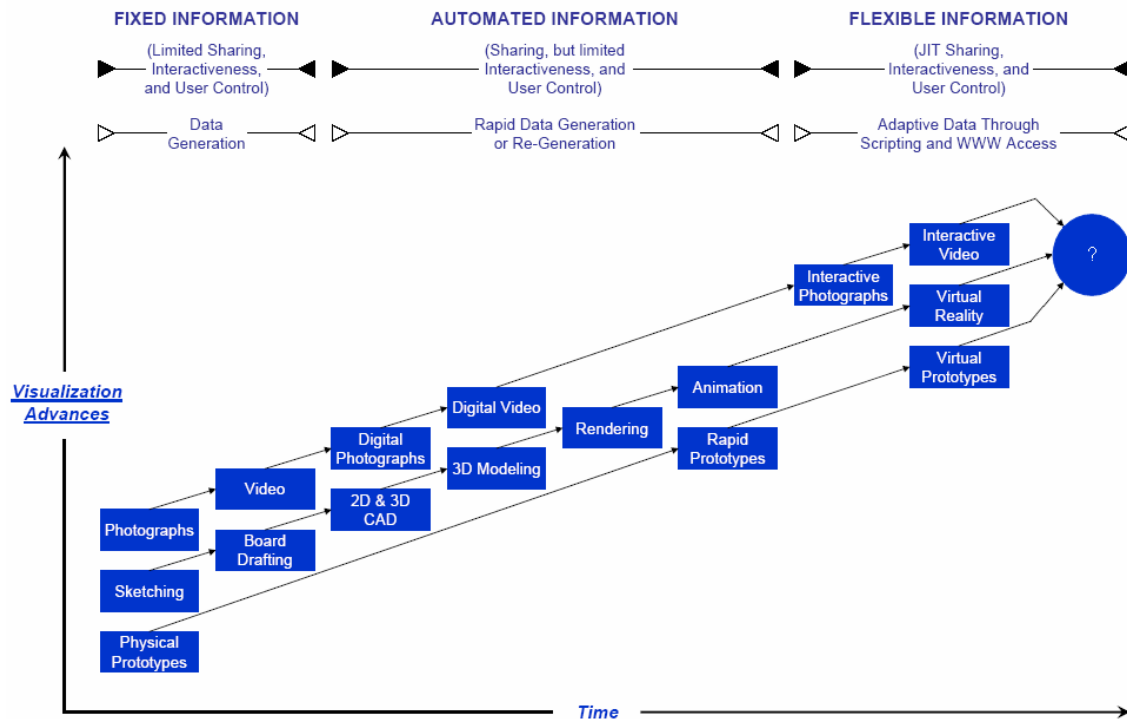


Figure 4. Visualization Construction and Information Sharing

Fixed information visualization techniques have existed for generations. The ability to convey ideas with pictures, sketches and prototypes (objects, symbols, etc.) have been refined over the past four decades. The very methods to generate visual information have become automated through digital means. Current processing capabilities have made it possible to produce in minutes, what might have taken an expert days to produce ten years ago; visualization results can be produced more accurately and quickly. We are currently evolving into an era where interactivity, adaptability, and the flow of information are vital. The right data must be conveyed to the right person at the right time. Users (customers, purchasers, students) want information just-in-time that they can control, or interact with to obtain what they need.

## Web-Based Visualization Applications

Visualization techniques and applications are changing the way instruction is carried out. For instance, concept maps are used to provide visual relationships of various forms of information. These visual representations of propositions can be used to link areas of knowledge together in a hypermedia format. Figure 5 shows a sample on-line concept map that links different manufacturing content areas. Colors, symbols, and directional arrows used in the maps indicate hypermedia links to other areas and categorize the flow of information.

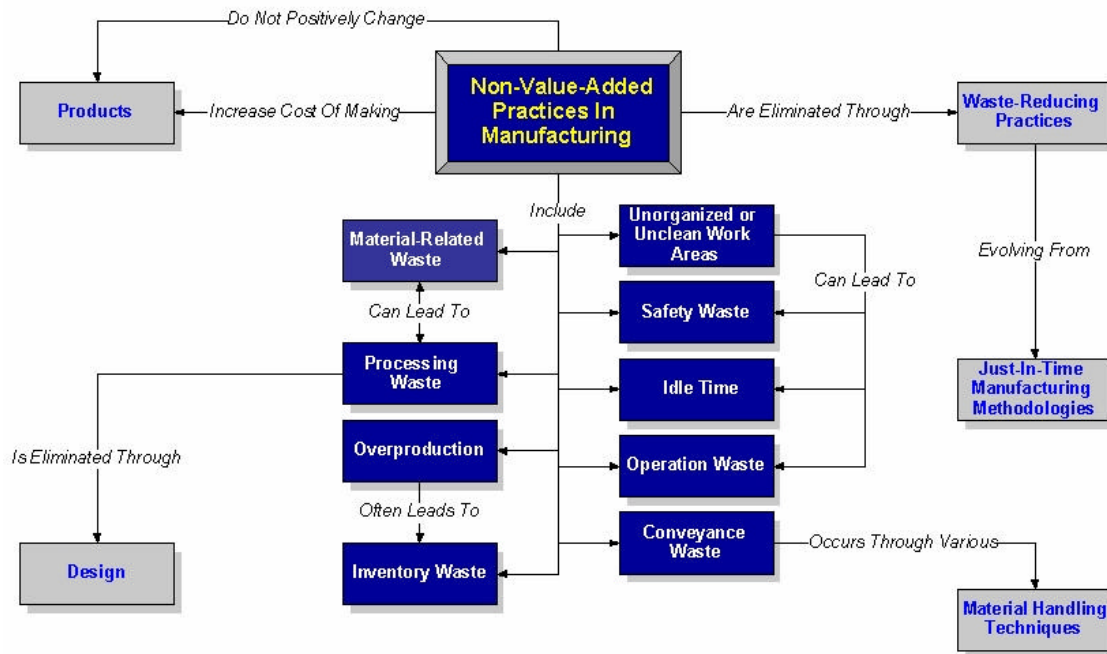


Figure 5. On-Line Concept Map

According to Novak and Gowin (1984), concept mapping is a visual roadmap of propositions, or are routes to construct meanings of concepts. Concept mapping is being used for a variety of age groups in numerous fields as a learning and problem-solving tool. For example, in the nursing field, concept mapping has been found extremely useful in diagramming and visually depicting clinical problems and interrelationships with the proper care and treatment procedures to students (Schuster, 2000). In another study of special education and remedial seventh graders, concept mapping was found as a useful to help the students plan, organize, and comprehend information from readings (Guastello, Beasley, Sinatra, 2000). A 2001 study revealed that concept mapping was an integral part of the positive results achieved by eleventh grade students' and their understanding of the human circulatory system (Sungur, Tekkaya, Geban, 2001). Alpert and Grueneberg (2000) explain that traditional concept mapping is evolving from traditional paper-and-pencil to computer-based tools, and commercial software is allowing both audio and visual information capabilities to be integrated with conceptual maps. They emphasize the potential benefits of video and other audio-visual technologies in maintaining the student interest as well as using the World Wide Web for students to engage in research activities. An on-line concept map can potentially link together content areas to help fill "knowledge gaps" that students might have because of traditional curriculum structures or lack of practical experience.

On-line animations can prove to be very educational. The North American Die Casting Association has placed numerous animations with text and audio support on the web (<http://www.diecasting.org/faq/>) to illustrate and explain how different casting processes work. Of course, what actually occurs internally in the casting process cannot be viewed, so the animation of the process can be very powerful. Traditional forms of illustration, including still photographs, video have been used to show casting processes externally, but cannot show the internal operations. Additionally, pictorial illustrations are not as descriptive as an animated approach. Because of these reasons, the animations provided by The North American Die Casting Association can be useful for anyone in industry or education wanting to learn about the internal operations of casting processes. Merrill (2002) claims that using examples that support presented information increase learning, and instruction should focus on real-world tasks. For technology educators involved in the teaching of manufacturing processes, visualizations such as these can assist in student understanding of real-world tasks. Figure 6 shows three phases of an animated casting process.

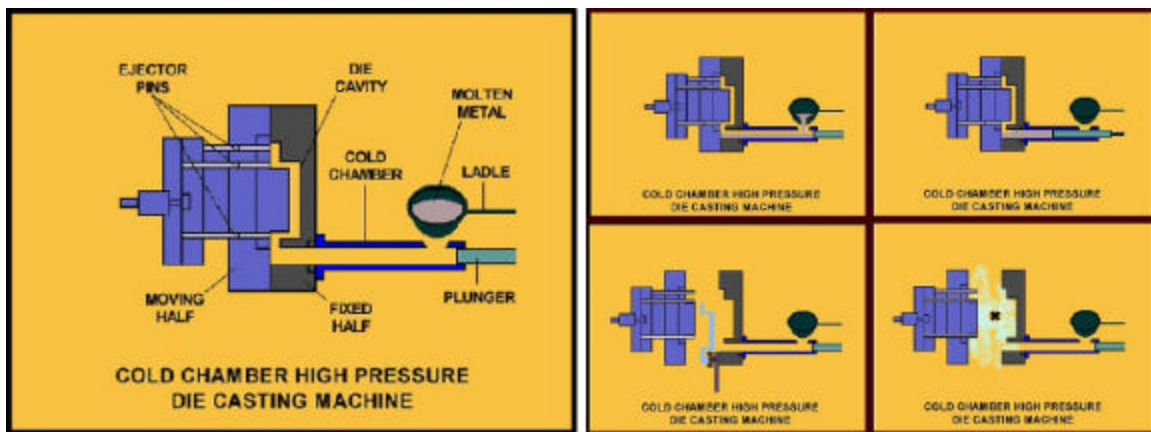


Figure 6. Animated Die-Casting Process (Courtesy of NADCA, October 14, 2004)

### Designing a Third Data Dimension through Layers

Effective instruction allows learners the opportunity to apply newly acquired skills (Merrill, 2002); Hemphill (2000) adds by writing, “There should be opportunities for practice, and this practice should involve more than just remembering” (p. 26). Hypermedia supports interactivity and can provide practice opportunities for learners.

Keirns (1999) describes three dimensions of information. In this, the learner can navigate from one block of information to another and can explore within each of the blocks of information if they desire. This can be set up in hypermedia designs through the use of layers; layers will allow the learner to navigate from concept to concept, and if desired, explore a concept in further depth. Figure 7 illustrates the idea behind layering information.

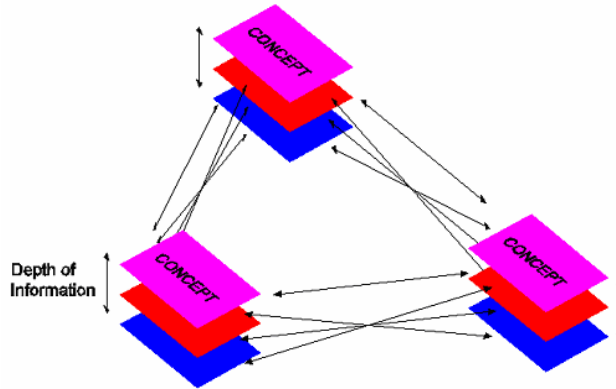


Figure 7. Illustration of Hypermedia Layering of Information

Many software programs enable the layering of information. This can allow the designer to set conditions of what is viewed and when. Hotspots, or particular areas of visualization, can be highlighted and activated through a condition, often referred to as a behavior. As an example, if a user left-clicks (the behavior) with a computer mouse on a hotspot (the target) of an image, then a new layer appears (the action). The behavior assigned to the hotspot is the physical mouse click. This capability is offered in VRML and movie scripts also. The control from one block of information to another is control of two dimensions of information; the control of information depth is control of a third dimension of information. In technical instruction, this ability can prompt learners to respond to what they see or identify, or can allow them to explore visual information at a deeper level.

Figure 8 provides an example of the procedures used to generate an interactive image (using layers) in Dreamweaver. There are four simple steps to creating interactivity for still images. The red circle in each image indicates the respective button to perform each step. Once the steps in Figure 8 are complete, the image can be saved as an HTML file. When the file is opened in Internet Explorer, and the user selects the hotspot with a mouse click, the selected layer (RightLabor in this case) will appear. There is no limit to the number of hotspots, layers, or behaviors that can be used for a single image. Layers can contain text, other visuals, web links, and audio.

A similar approach to designing interactivity can be made in VRML models. First introduced in the mid-1990s, VRML is a real-time rendering language designed for viewing three-dimensional scenes over the World Wide Web. VRML was originally based on the OpenGL® Inventor, an object-oriented toolkit for developing interactive graphics developed by Silicon Graphics Inc. (SGI). VRML browsers interpret scene descriptions and render the resultant image through a virtual camera in real-time. Users are permitted to visualize or walk around three-dimensional “virtual worlds” from any viewpoint. This incorporates six degrees of freedom including movement and rotation along the XYZ axes. VRML features include geometry, materials, textures, geometric transformations, lighting, viewpoints collision detection, texture-mapped backgrounds, contoured terrains, surface mapping, and nested structures.





Figure 8a – Insert the desired image. The image may need to be reduced in size.

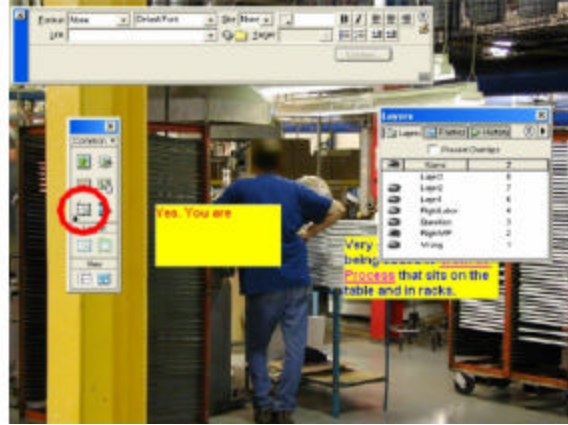


Figure 8b – Create desired layers and their content. As layers are generated, they have the option of being visible or hidden. In the Layer panel, the eye column indicates whether a layer is hidden or visible. For this exercise, all layers will be hidden after generation.

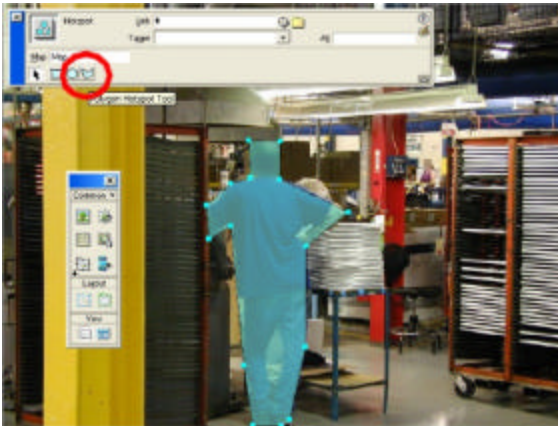


Figure 8c – Create the hotspot area(s) that the user can select.

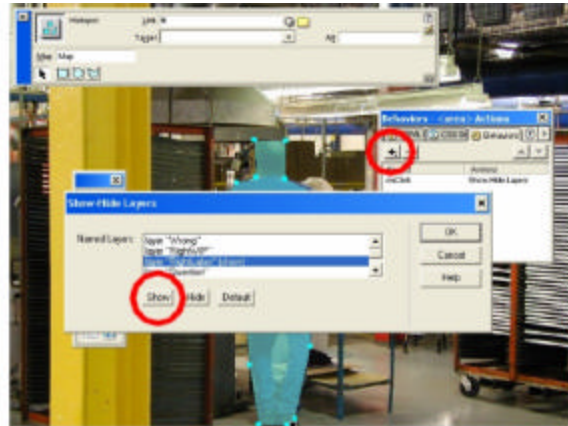


Figure 8d – Select the hotspot, and open the behavior window. Select the “+” to add a behavior. A menu will appear providing many choices. Select “Show-Hide Layers”. Select the layer to appear when the hotspot is selected (in this example, RightLabor is the selected layer) and select the Show button (circled on the Show-Hide Layers window). After this, the desired behavior (e.g. onClick, onMouseOver, onDoubleClick, etc.) can be selected under “Actions” in the Behavior panel. In this exercise, onClick is selected.

### Figure 8. Creating Interactive Images in Dreamweaver

Figures 9 and 10 illustrate a simple interactive three-dimensional virtual model. In addition to being able to manipulate the model in real-time, the user can select any face; upon doing so, the standard orthographic views for the object will appear in a separate window. The separate window containing orthographic views is essentially a hidden layer of information. On that layer, the user can select “Click HERE to display dimensions” if desired. This will call up another layer containing orthographic views with their associated dimensions.

```

#VRML V2.0 utf8
NavigationInfo { type "EXAMINE" }
Background { skyColor [1 1 1] }
DEF Sample_Geometry
Anchor {
  children [
    shape {
      geometry IndexedFaceset {
        solid FALSE
        coord Coordinate {
          point [ -1.5 -1.5 1.5, 1.5 -1.5 1.5,
                 1.5 .125 1.5, -.125 1.5 1.5,
                 -1.5 1.5 1.5, -1.5 -1.5 -1.5,
                 1.5 -1.5 -1.5, 1.5 .125 -1.5,
                 -.125 1.5 -1.5, -1.5 1.5 -1.5 ]
        }
        coordIndex [ 0, 1, 2, 3, 4, -1
                    1, 6, 7, 2, -1
                    2, 7, 8, 3, -1
                    3, 8, 9, 4, -1
                    4, 9, 5, 0, -1
                    0, 5, 6, 1, -1
                    5, 9, 8, 7, 6, -1
                    ]
      }
    }
  ]
  appearance Appearance { material Material { diffuseColor 0 1 1 } }
}
url "drawing1.htm"
description "Object views"
parameter ["target=_blank" ]
}

```

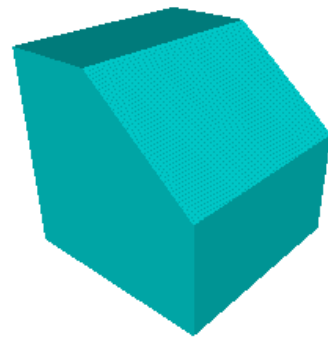


Figure 9. Interactive VRML Model

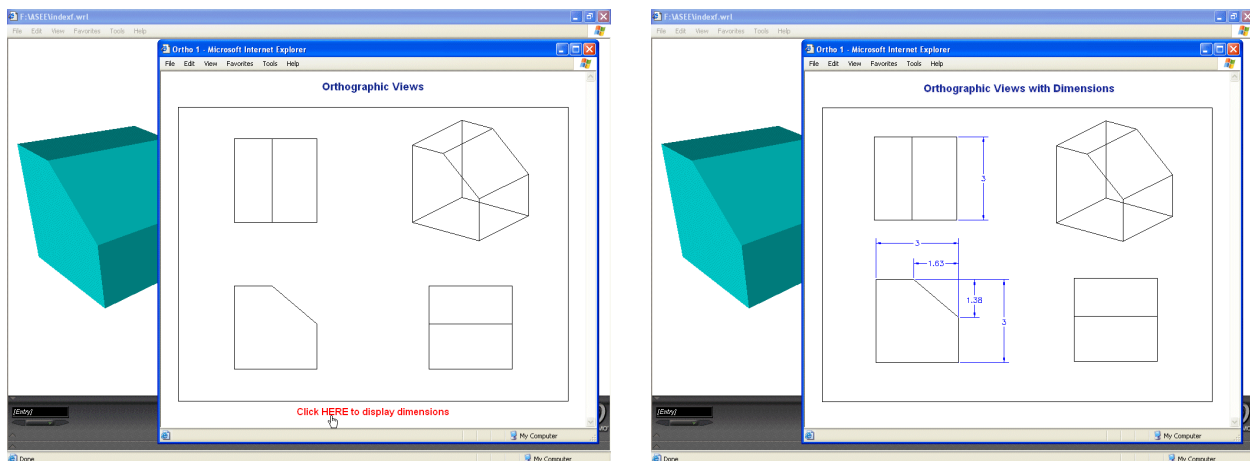


Figure 10. Interactive VRML Layers

The capability of layering information in VRML models can be extremely valuable in teaching planer concepts and illustrating proper part detailing. To further develop the model in Figure 9, each individual face can have a separate layer detailing views (Figure 10) from any specific perspective. The instructional designer can create additional hotspots in the virtual model or links in hidden layers that show section views, dimensions, etc. The number of layers and links is unlimited. Today, the capabilities of VRML are part of X3D, the newest standard for real-time communication of 3D data.

Interactive video relies on the same principles as seen and described in Figures 8, 9 and 10. Many instructional designers (including the authors) have found Macromedia's Flash software to be well suited for developing interactive web-based videos. Videos should be edited in a standard program (e.g. Pinnacle Studio, QuickTime Pro, etc.) and be compressed (Sorenson Squeeze, DivX, etc.), before importing into Flash. Flash utilizes layers, buttons as hotspots, and behaviors which determine the condition changes. The number of scenes that can be generated for different scenarios is boundless.

The instructional process should support opportunities to choose, provide immediate feedback, overcome accessibility issues, allow users to control the pace of learning, and support multi-sensory techniques. Hypermedia seems to be an appropriate delivery approach to support instruction. With the Internet, the possibility exists that any location can be reached. Because students do not learn at the same pace and may have differing needs, instruction should account for individualized learning. Considerations should be made to present information in a non-linear format, to allow users the choice of how much or how in-depth they wish to investigate that information, to provide immediate knowledge of progress, and to have the opportunity to view information from different perspectives. All of these ideas are put into practice using visualization techniques in the previous examples.

## Conclusion

Visualization with the use of the Internet is playing an increasingly important role in product development, collaborative design, and industrial training. Web-based visualization is also paving the path for more effective instruction by supporting interactivity in the technology field. Time, distance, and access are no longer constraints in education or industry. Hypermedia technology supports interactiveness which is seen as necessary for learning to occur. "Faculty who operate within the confines of the Traditional Instructional Paradigm are less likely to perceive and exploit the full learning potential of the technology" (Buckley, et al., 1999, p. 3).

Web-based visualization can provide an innovative and appropriate approach to providing technical instruction. This requires educators to examine their current practices and teaching/learning theories. If educators believe that active participation promotes learning, this should be acknowledged in instructional practices. Rada (1995) uses a Chinese proverb to describe the power of doing to reach understanding; Rada (1995) writes:

I hear, I forget  
I see, I remember,  
I do, I understand (p. 32-33)

The Internet can support a wide variety of visualization approaches, offer learning opportunities that link workforce practices, assess student performance, provide practice opportunities, foster communication, and share information over any distance. Educators who understand learning theory, learn instructional technology capabilities, and observe workforce needs will redefine instructional design and create more useful tools for technology education.



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