

Applying Cognitive Theory to Developing Effective Electronic Presentations

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SUMMARY. Examining evidence from psychology regarding human memory and the cognitive processes that enhance the likelihood that information is perceived, attended to, and comprehended provides a good foundation for development of visual presentations. Electronic presentations afford educators the flexibility and capabilities that can assist them in creating effective presentations. The flexibility of these newer technologies is addressed and their capabilities are examined through a series of useful tips and techniques for using these technologies to create presentations. [Article copies available for a fee from The Haworth Document Delivery Service: 1-800-342-9678. E-mail address: getinfo@haworthpressinc.com <Website: <http://www.haworthpressinc.com>>]

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INTRODUCTION

Classic visual information presentation tools used in educational settings are being replaced rapidly by newer, more flexible technolo-

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gies. Enticement to replace the traditional educational tools, like the blackboard and overhead projector, is coming from increased availability of technologies to display visual information and increased proficiency in the use of these technologies. These technologies offer certain advantages over traditional methods of displaying visual information.

Visual information is used by educators during presentations for a number of reasons. This teaching strategy can be used to emphasize important information, clarify concepts being presented, and organize the information presented. However, many educators may use slides or provide other visual information just because it is what they have always done. This may make it difficult for them to understand why newer technologies should be employed. Instead, the justification for newer technologies should be based upon additional benefit to the students, the educators, and/or the institution. These benefits can be examined effectively by reviewing the cognitive aspects of using visual information during presentations and discussing how these technologies can be effectively employed to benefit educators.

COGNITIVE PROCESSES

The ultimate goal of most presentations is to convey information in a manner that allows the recipients to learn the information being presented. Learning involves a complex, interrelated series of cognitive processes, including memory, perception, attention, and comprehension. While application of knowledge is the ultimate goal, Ormrod states that “learning a piece of information does not guarantee that the information will be remembered later on. A number of variables determine what information gets into memory in the first place and what information stays there long enough to be remembered when it is needed” (1). Despite this inability to ensure memory and recall of information, educators should maximize the likelihood that presented information will be stored in the memory of the information recipients. A review of the cognitive processes involved in memory will assist educators in accomplishing this goal. While this review does not present all of the theoretical findings on each cognitive process, it provides a description that will assist educators in determining whether technologies will assist them in accomplishing their educational objectives.

Human Memory

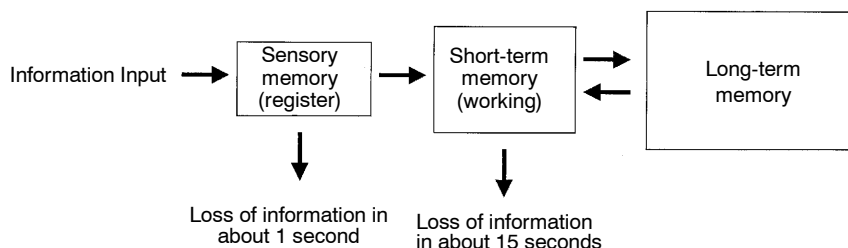
In 1968, Atkinson and Shiffrin proposed a model of human memory that has three components: sensory memory, short-term memory, and long-term memory (2). Each type of memory—sensory, short-term and long-term—handles information in a different way and retains it for a different length of time (Figure 1).

Sensory memory (also referred to as the sensory register or iconic memory), is the first type of storage. Sensory memory registers/perceives input from the environment and holds the information very briefly (about 0.5 to 1.0 second for vision and 3.0 to 4.0 seconds from hearing), just long enough for it to be selectively attended to and identified for further processing in short-term memory. The memory can be a sight, a sound, a touch, a smell, or a taste, and unless it is processed and thereby transferred to another part of the system, the memory will fade in about a second. Sensory memory contains everything impinging on our senses, including not only what we hear and what we see but also background distractions that we tune out. Sensory memory can hold a great deal of information at one time, but because the information is unprocessed, it has no meaning. Further, the tremendous amount of information is quickly lost if it is not processed (3). Ormrod gives the following example of sensory memory:

When you sit in a classroom for an hour or more, your attention will most inevitably wander away from the instructor at some point. You may have noticed that when you tune back in to what the instructor is saying, you can often recall two or three words that the instructor has said before your tuning in. Virtually, everything the instructor has uttered has probably been recorded in your sensory register despite your mental absence from class, but alas, only those last two or three words are still there when you decide to be present again. (1)

Information that has been processed by the sensory register moves on to **short-term memory** (also referred to as working memory). Short-term memory, the second type of memory storage, is that component of memory in which the most active processing of information takes place. Short-term memory contains all of the information that we are thinking about and working on right now (2). The information in short-term memory has meaning; the sensory information has been

FIGURE 1. Overview of the Information-Processing System.



transformed so it can be processed and understood. However, short-term memory can only hold a limited amount of information for about 15 seconds, and unless processing of the information continues, the information is lost.

The final component of the Atkinson-Shiffrin model is **long-term memory** (2). Long-term memory can be considered the repository of permanent knowledge, a library of information. Long-term memory appears to have limitless capacity and storage that lasts for years or decades. Tulving classified long-term memory into two types: episodic and semantic (4). Episodic memory refers to storage and retrieval of personally dated, autobiographical experiences such as remembering what you had for breakfast or recalling childhood experiences. In contrast, semantic memory refers to memory of general concepts and principles and their associations. Unlike episodic memory, semantic memory is not linked to a time or place.

Information in long-term memory is stored (encoded) in a number of different forms, including verbal codes, imagery, propositions (small units of knowledge), and productions (procedures involved in performing a particular task). Information in long-term memory is interconnected in an organized fashion so that related pieces of information are associated with one another. Information that is transferred to long-term memory is related meaningfully to other information already in storage.

This description of human memory simplifies an extremely complex system of cognitive processes and omits many of the findings about how these processes function. However, this description amply delineates a foundation upon which an understanding of the role of visual presentations in education can be built. Given that visual pre-

presentations generally accompany the presentation of verbal information, it is apparent that presentations have the potential to influence the entrance of information into sensory memory and the processing of information that takes place in short-term memory. It is likely that presentations that facilitate the flow of information in these two memory types will be most effective. Therefore, several key processes that affect these two types of memory are important to consider when developing visual presentations.

Perception, Attention, and Comprehension

There are many cognitive processes that affect the flow of information from sensory memory to long-term memory. Three important processes that influence the processing of information in sensory and short-term memory are perception, attention, and comprehension. These processes play critical roles in the learning process as well. **Perception** refers to the meaning (the recognition and interpretation) that one gives to the environmental stimulation.

Information that is not attended to in the sensory registers is lost. The remaining information is rapidly compared to one's knowledge and assigned a preliminary meaning. This is referred to as pattern recognition, and is responsible for the identification of thousands of specific sensations and images. (5)

“Knowledge directly influences perception, pattern recognition, and the assignment of meaning. Knowing what we see (or hear) and even how to look (or listen) depends on the knowledge we have” (6). Bruning and colleagues describe the following example: “An expert chess player perceives midgame chessboards very differently from a person who has never played the game. The expert sees that a king is in check, that a certain defense style is being played, and so on, whereas a nonplayer merely perceives pieces in a different way” (6).

Learners will typically assign meaning through perception to every aspect of a presentation. Since learners usually process only 1/100 of their environment, care must be taken to produce stimuli that appropriately occupy their perception while minimizing communication noise (unintended messages) that could distract them (7).

Interwoven with perception is attention. A great deal of information gets into sensory memory, but it is quickly lost if it is not attended to

by the recipient (3). Gredler states that “two important factors in the determination of the information that is perceived are learner attention and the learner’s knowledge” (5). **Attention** is the process by which people select some of the environmental input that they receive for further cognitive processing. Attention plays a central role in learning and memory; it moves information from sensory memory to short-term memory. In essence, information to which one pays attention advances to short-term memory, whereas information that is not attended to may be lost from the memory system. For example, as you read this page, you may also be listening to music, eating a snack, responding to interruptions, or making a list of key points. What you perceive at any given moment depends on how your attention is divided among various tasks. If most of your attention is devoted to the music, you may not correctly perceive the meaning of some of what you are reading (6). At the heart of attention is the motivation of the information recipient to (a) dedicate the perceptual processes (mainly listening and observing in instructional settings) necessary to receive and process the information being presented and (b) block the unwanted distractors that may interfere with information processing (8).

Interwoven with perception and attention is **comprehension**. Since 1940, it has been proposed that the cognitive processes of organization and memorization are inseparable (9). Information is cognitively organized by connecting the information presented to knowledge that is stored in memory (8). Optimal organization can occur only if the information is comprehended, or understood. In other words, information that is presented so that it is understood has a better chance of being optimally organized and, as a result, has the best chance of being remembered. A classic experiment by Bransford and Johnson demonstrated this link among understanding, organization, and memory (10). Subjects were given the following passage:

The procedure is actually quite simple. First you arrange items into different groups. Of course one pile may be sufficient depending on how much there is to do. If you have to go somewhere else due to lack of facilities that is the next step; otherwise you are pretty well set. It is important not to overdo things. That is, it is better to do too few things at once than too many. In the short run, this may not seem important but complications can easily arise. A mistake can be expensive as well. At first, the

whole procedure will seem complicated. Soon, however, it will become just another facet of life. It is difficult to foresee any end to the necessity for this task in the immediate future, but then, one never can tell. After the procedure is completed one arranges the materials into different groups again. Then they can be put into their appropriate places. Eventually they will be used once more and the whole cycle will then have to be repeated. However, that is part of life.

Can you guess what process is being described here? Most subjects were puzzled by the passage. However, the subjects who were given the title “Doing the Laundry,” before they read the passage easily understood it and did well on a memory test of the information. Subjects who read the passage without the title did poorly on a memory test. This phenomenon has been demonstrated with images as well (8).

The implication of the cognitive processes involving understanding, connection, and memory is that information must be presented so that it is understood to maximize its chance of being remembered. Visually presented information can facilitate the understanding of verbal information. Slides that contain outlines, for example, can help students understand the information being presented as well as help students to organize it in an effective manner.

Implications of Cognitive Processes for Instructional Design

These cognitive processes have several implications for learning and instructional design. Given that perception, attention, and comprehension will affect the processing of information, creating presentations¹ that facilitate these will improve the likelihood that they are effective in enabling memory of the information. An obvious recommendation is that information should be presented so that it can be perceived. While this recommendation seems obvious, the implications for presentation design are considerable. Slides that contain a lot of information may interfere with the students’ abilities to perceive the concepts being presented. Given that short-term memory is limited in capacity, educators should not present too much new information at once or require unduly complex cognitive processing by students. Likewise, educators who write on the board in an unorganized way will not only hamper perception, but also prevent those who have

“tuned out” from catching up once they tune back in; i.e., unorganized and cluttered information will inhibit information perception.

Visual presentation tools can be used to “jazz up” presentations in a way that motivates students to pay attention to them. Newer technologies easily incorporate colors, sounds, and images that can be used to encourage students to pay attention. However, this must be done in a way that does not distract from the information being conveyed. It is difficult to prescribe specific strategies that will ensure attention and minimize distraction, but instructors can rely upon their judgment and feedback from colleagues and students to refine their attention-getting methods. Another method to keep students focused on the lesson is to use variety and novelty in the subject matter and the mode of presentation. Also, use questions at the beginning of the presentation to direct students’ attention toward information that answers the questions.

Presentations can be used to facilitate comprehension also. Even something as simple as an outline of the material to be covered written on the board can help students to understand the material. It provides organization and structure that will help them to understand the topics being covered. Clear explanations and demonstrations ensure that learners understand the content. Asking the learner questions, checking for understanding, monitoring the learner’s work, and providing corrective feedback ensure proper learning and allow for correction of errors before faulty learning becomes established. Technologies that are more sophisticated than a blackboard and overhead projector can be used to facilitate comprehension. The main benefits to using these technologies are enhanced flexibility and capabilities.

In summary, the primary goal of teaching and training is to enable people to store and retrieve information from long-term memory. The storage of information in long-term memory is dependent upon processing the information in the sensory memory and short-term memory. Instructional media can be used to enable the flow of information to memory by facilitating perception, attention, and comprehension. Therefore, when developing electronic presentations or any instructional media, educators should try to increase learning by:

- Beginning the presentation with an outline listing important points
- Using various letter sizes, bright colors, or emotionally strong stimuli that are easily perceived and that attract the attention of the learner

- Helping learners select important information by highlighting it, building in redundancy (slides that convey the material being verbally communicated in the same or a different way), and connecting it to previous information
- Using uncluttered materials that concisely organize the information to be presented
- Showing demonstrations and pictures rather than just talking about them.

ADVANTAGES OF ELECTRONIC PRESENTATIONS

To justify expending time and financial resources to acquire, learn, and maintain the hardware and software necessary to create and present computer-assisted presentations, there should be a clear understanding of (a) the advantages offered by the technologies and (b) how these technologies can foster perception, attention, and comprehension. This understanding necessarily begins with an overview of the technologies that are available.

Overview of Technologies

The presentation technologies can be divided into software and hardware categories. The software is the computer program used to create the presentation. The author of the presentation would use the computer program to create a presentation. Most commonly, this is done using a presentation program like PowerPoint® by Microsoft or Corel Presentations® by Corel. Of the software available, presentation software provides the most choices with regard to presentation format. Content for presentations also can be developed using word processing programs, like WordPerfect® by Corel or Word® by Microsoft, and multimedia software, like Authorware Attain® and Director® by Macromedia and Hyperstudio® by Roger Wagner Publishing.

Once the content for the presentation is developed, it must be stored and then displayed—this requires use of the hardware technologies. Hardware technologies used to make electronic presentations include computers, media, and projectors. These are the actual devices used to create, store, and display presentation information. Laptop computers offer the most functionality in making electronic presentations because they can be carried into the classroom. The created presentation

is generally stored on the hard drive of the computer, but it can also be stored on media such as floppy disks, compact discs (CDs), and digital versatile discs (DVD). These offer different storage capacities, with the floppy disk holding the smallest amount of data and the DVD holding the most at 17 gigabytes of data. Another option is to create the presentation on the web and then display it using a Web browser. (Course support offered by the World Wide Web is discussed by McCaffrey et al. in this issue.)

A projector is used to display the presentation created. The information can be (a) printed on transparencies and displayed using an overhead projector, (b) photographed, developed on slides, and displayed using a slide projector, (c) sent directly from the computer to a liquid crystal display (LCD) projector, or (d) printed and then displayed using a video camera that is connected to a projector (e.g., ELMO).

The cost of displaying presentations can be a particularly important consideration, especially if one is trying to outfit several classrooms. For example, consider the difference in price between an overhead projector, which costs a few hundred dollars, to the price of an LCD projector that displays computer presentations and costs several thousand dollars. The capability of presentation software to produce paper handouts, 2 × 2 - 35 mm slides, and black and white (or color) overhead transparencies should be taken into consideration when planning for an academic or corporate approach to presentation development. In other words, budgeting a \$5,000 LCD projector for every classroom, meeting room, and auditorium may not be necessary, while the expense of presentation software, which can create transparencies, electronic presentations, and handouts, may be justified. However, if the LCD projector gets considerable use, its cost is likely to be offset by the savings generated by not having to create transparencies and slides.

The method of projection that is chosen by an institution and an instructor also should be based upon a determination of how the information should be projected to facilitate perception, attention, and comprehension. For example, colors can be incorporated into a presentation and can be projected from color slides, from color transparencies, or directly from the computer to an LCD projector. However, demonstrations, animations, and other multimedia presentations require a projector that is directly connected to the device that is playing the presentation.

The advantages of projecting presentations directly from the computer are primarily flexibility and capability. When multimedia assets are converted into digital formats, the flexibility given presenters is substantial. For example, a presentation technique called **progressive disclosure** requires that a presenter who has a list of six items to discuss must stand at an overhead projector and cover items two through six with a sheet of paper to focus audience attention on the first item. In an electronic presentation, lists can be revealed one item at a time, and the speaker, with a wireless mouse, can control the presentation while standing in the audience or at a podium. **Customization** and **late-breaking events** can be incorporated into the presentation moments before the presentation is made. This would be impossible with other media formats.

Videos can be digitized and presented directly from a computer to a projector also. Video presentations are usually made in a linear format, which makes selecting and commenting on specific information a difficult task. Video information that has been converted to a digital format can be inserted in a “just-in-time” fashion. This allows small segments of the material to be presented, and the speaker can provide commentary on each segment. It is often difficult to control a VCR in this manner. When access to specific information is required in a presentation, perhaps to an audience-generated question, it can be effortlessly retrieved from the digitized file. With the introduction of DVD, it is now possible to have full-screen, 30-frames-per-second images that exceed the quality of VHS or laserdisc.

Other flexibility accrued through the use of computer-based presentations includes the capability of distributing the materials by **electronic mail** (e-mail) or by **electronic publication** on a web server. Electronic presentations offer collaborative teams the ability to share and edit materials online. Finally, the ability to easily incorporate multimedia assets into the materials improves the visual appeal of the presentation and increases the ability to facilitate perception, attention, and comprehension. The flexibility that is afforded by computer-based presentations is complemented by the increased capabilities of the software packages that can be used to create these presentations. These capabilities are best described through a series of tips that can be used to add colors, images, and multimedia segments to presentations.

Working with Multimedia Assets to Create Presentations

Computer-based presentations afford educators the capability to facilitate perception, attention, and comprehension. What follows is a list of the most useful techniques employed by the authors in the creation of over 1,000 computer-based presentations. Presenting the techniques with information as to how they can be employed accomplishes three goals: (1) it demonstrates the capabilities of the computer-based presentation, (2) it demonstrates how the computer-based presentations can facilitate perception, attention, or comprehension, and (3) it provides information as to how the technique can be accomplished.

Background Designs. Presentation software offers a variety of backgrounds, text justification options, and color schemes to presenters. Unless the presenter has artistic training, it is usually better to stay within the preformatted templates offered by the application. Remember that high contrast between the text color and background color is usually required for best viewing (facilitating perception). The backgrounds designed into the software do not have to be used, but be aware that consistency can be lost if instructors custom design each slide.

Use Appropriate Font Sizes in Presentations. To promote perception and attention, instructors need to be aware of the size and dimensions of the room in which presentations will be made, as well as the size of the audience. Presentation software will typically allow the font size to be adjusted so those audience participants in the back of the room will be able to read projected text. When the Internet and browsers are incorporated into presentations, it is possible to enlarge browser text so that it projects embedded fonts appropriately. As a rule, type size should never drop below 24 points; there are 72 points in an inch.

Apply Transition Effects. All of the presentation software packages allow you to select transition effects between slides and text effects within a slide. Presenters need to use transition effects judiciously so that the number of special effects used will facilitate attention but not overwhelm audience participants. We suggest instructors choose one transition between slides and one method for introducing text onto the screen and use them throughout the presentation.

Copy Text from the Internet. In general, a majority of the slides in

presentations contain text. Text and outlines can enhance comprehension of the material, particularly if they organize the concepts to be presented. While it can be, not all of this text has to be typed in directly by the presenter. To acquire text from the Internet, or any on-line text source, simply highlight the text using the mouse (or the combination of the shift plus arrow keys), then click edit, and then copy on the Internet browser. Use the edit and paste feature in the presentation software to place the text into the presentation.

Care should be taken to give an attribution to the owner of the content. In most educational presentations, this can be done with a footnote. If there is any question of copyright infringement, permission should be sought from the owner of the material. Copyright laws should be considered and followed for all published text, graphics, animation, video, sounds, and Internet-based assets.

Copy Pictures from the Internet. Pictures can enhance comprehension of the concepts being presented. They can be acquired from the Internet using the right mouse button. Click on the picture you want and then highlight the “save image as” feature of the dialog box that appears. In the presentation package, use the “insert picture from file” sequence to place the picture in the presentation. Most presentation software also contains a library of clip art that users can insert into their presentations. Be aware that the inclusion of many photographs and graphics will rapidly increase the file size of the presentation. However, overcoming file size problems is worth the trouble if the images contribute to the students’ attention and comprehension of the materials.

Use Windows 95® or Windows 98® to Capture the Images on the Screen. Windows 95, 98, and NT® allow any image on your desktop to be placed in the Windows clipboard. By tapping the “print screen” key on the keyboard, the images shown on the entire screen will be captured. In the presentation software, simply use the edit and paste functions to place the image of your desktop screen into the presentation.

Select Specific Software Program Screen Images for Copying. To capture the images in the active window on the screen only, eliminating the desktop’s background material, hold down the “Alt” key and tap the “Print Screen” key on the keyboard. The edit and paste sequence can be used to place the image into the presentation. This feature is especially helpful when you want to teach the learner about a

new software program or when you have created an image in a program that does not allow you to copy it from one program to another.

Incorporate Objects into a Presentation. The term object refers to those multimedia assets used in presentations such as pictures, text, drawn shapes or lines, scanned images, and movie/animation frames. Presentation software allows presenters to move, crop, and/or resize these objects on an individual slide within the presentation. Before an object can be moved it must be selected. Clicking on an object, using the mouse, selects the object and reveals the handles or anchors of the object. A 4-headed arrow allows presenters to reposition the object on the slide or within the document. Clicking on a corner handle allows presenters to resize the object proportionately. Clicking on a side or top handle allows presenters to stretch the object in one dimension. Objects can be sized so they are visible to the students and so text descriptions can be added if they are necessary to ensure comprehension of the concepts.

Importing Hard Copy Materials. If the educator has access to a digital scanner, forms, documents, printed diagrams, and photographs can be digitized into files that can be inserted into presentations. This capability allows educators to incorporate into their presentations any type of hard copy material that might facilitate comprehension.

Digital Photography. There are a wide variety of digital cameras on the market. The advantage of the digital camera is that it creates a file output that can be imported directly into a presentation. Some presentation products will allow videotape cameras to feed images into the computer. Once the photographs are stored on the computer, they can be inserted into a presentation. This technology allows the educator to skip the film development step of incorporating photographs into presentations; this saves not only time but also money.

Movies and Sounds. Inserting animation sequences, video clips, and narration or sound effects can be accomplished with presentations. There are many instructional videos that can be used to facilitate attention and comprehension of the materials being presented. Incorporation of these into presentations often requires having a player and a television on hand and preparation time to cue up the video portion that is of interest. By incorporating these clips into the presentation, the presenter can play, stop, and replay the clip on demand. This is accomplished during the showing of the presentation by clicking on the object that represents the animation or the sound. Movie and sound

files can be obtained from sources like CD-ROMs and the Internet, or they can be created by presenters who have the appropriate hardware. File formats that can be used include: AVI, MPG, and MOV.²

Embed Hyperlinks in the Presentation. There is a tremendous amount of information available on the Internet that can be used to encourage attention and facilitate comprehension. Presentation software is becoming more integrated into the Internet. If presenters have an active connection to the Internet during their presentation, hyperlinks will activate the computer's browser and automatically call a web site into the presentation. By embedding the link directly into the presentation, one does not have to switch to an Internet browser and then call up the site; the presenter only needs to click on the link and the computer brings up the browser and displays the site automatically. This hyperlink can also use the browser to display HTML pages stored on the hard drive. Hyperlinks are inserted into presentation slides by using an "insert hyperlink" feature of the software.

In summary, the newer technologies afford educators flexibility and capability that can facilitate effective presentations. And, it is the combination of both flexibility and capability that justify employment of these technologies. Efficient presentations that display information seamlessly are likely to minimize distractions, facilitate attention, and foster comprehension. These advantages, coupled with the reduced cost of creating presentations and the flexibility to improve presentation content yearly, make these technologies extremely useful educational tools.

CONCLUSION

Visual presentations can be valuable counterparts to verbally presented materials. They can ensure that the materials being presented are perceived, attended to, and comprehended. Presentations should be developed with these goals in mind. Electronic hardware and software can assist educators in accomplishing these goals. While advanced technologies are not essential tools in meeting these goals, they offer considerable flexibility and capability when developing presentations. The functionality of these technologies makes the educator's imagination the only real limitation. We are confident that with only a little experimentation you'll be able to make effective presentations that achieve your educational objectives.

NOTES

1. The term *presentations* used here and in the remainder of the document refers to visually presented information. This should not be interpreted as slighting the importance of verbally presented information that generally accompanies visual presentations.
2. Using the find feature in Windows Explorer®, presenters can examine their computers and CD-ROMs for the availability of these files by searching with “*” preceding each of the file extension types. The same process can be followed on the Internet by placing the file extensions into a search engine such as Altavista (located at <http://altavista.digital.com>). Searchers should use an additional keyword, e.g., “diabetes,” in their search to avoid selecting undesirable material.

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