Instructional Strategy: Didactic Media Presentation to Optimize Student Learning

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Context: Subject matter is presented to athletic training students in the classroom using various modes of media. The specific type of mode and when to use it should be considered to maximize learning effectiveness. Other factors to consider in this process include a student's knowledge base and the complexity of material.

Objective: To introduce instructional strategies within the didactic component of an undergraduate or graduate athletic training program that effectively address split-attention, redundancy, and modality effects, which in turn will minimize extraneous cognitive load and optimize working memory storage capacity.

Background: With technological advances in education, a vast assortment of content in athletic training programs, and inconsistency in student learning styles, a variety of modes through which to present course material should be implemented for optimal learning. Traditional instructional strategies do not always respect the limited capacity of working memory and present information using media in a way that negatively affects learning.

Description: An explanation is given in the use of various media sources to present information within the classroom and to examine the impact they have on extraneous cognitive load and, ultimately, learning. Specific instructional strategies will be introduced that target the classroom presentation of information with the goal of minimizing split-attention and redundancy effects and optimizing the modality effect.

Clinical Advantage(s): To optimize athletic training student learning effectiveness through considerations in the various modes of media presentation with course subject matter within the classroom.

Conclusion(s): The presentation of material in athletic training education using a multimodal approach is essential to student interest and learning. Space occupied in working memory can be minimized when classroom presentation of material takes into consideration the split-attention and redundancy effects. Strategies consistent with the modality effect help expand the capacity to withhold information in working memory.

Key Words: Multimedia, split-attention, redundancy, modality

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INTRODUCTION

Athletic training programs consist of didactic and clinical components. The didactic component is required to cover a multitude of knowledge and skills within content areas of the National Athletic Trainers' Association's Athletic Training Education Competencies.¹ The areas covered require an indepth understanding of topics such as injury evaluation and treatment. They also require motor skills for special tests and manual therapy techniques. With advances in educational technology, various modes of media are available to introduce these concepts, such as pictures, videos, and diagrams that could require written or verbal explanations.

Studies inquiring about the type of media used to present information that students prefer along with their styles of learning have been conducted in healthcare professions. When students in the health professions² and medical fields³ were asked what type of mode they preferred information be presented in, both stated they wanted subject matter introduced using a variety of modes. If students present with differing styles of learning, it would be suggested that multiple modes of instruction be exercised with the intent to address the variety of styles. The types of learning styles were found to be inconsistent with both physical therapy⁴ and athletic training⁵ students. In fact, students who were interested in pursuing athletic training did not present with unique learning styles regardless of whether or not they were admitted into a program.⁶ Additional research⁷ using psychology students demonstrated that specific learning styles do not translate into greater learning outcomes, which suggests that students are likely multimodal learners. In addition, learning strategies may change with the context of material, requiring the adjustment of learning style regardless of the material.⁷ Consequently, since students in healthcare programs possess a variety of learning styles and prefer subject matter be introduced using various modes of media, multimedia presentations may be beneficial in optimizing the learning potential for students in athletic training programs.

The method of subject matter presentation and its timing could make a significant difference in learning. Consequently, specific educational strategies for a professional education program such as athletic training are critical for optimal learning in the didactic portion of the educational process. Several factors influence the manner by which information from multiple sources should be presented in the face-to-face classroom for optimal learning. These factors include student knowledge base, complexity of information, length of information, whether material is system-paced or studentpaced, and whether modes of information are presented concurrently or sequentially. To assist in understanding optimal presentation strategies that are consistent with the cognitive load theory of learning, a visual explanation of how this theory proposes the storage of information will be addressed. In the 1980s, Sweller⁸ suggested that information introduced to the mind first enters a short-term or working memory system where processing occurs before passing it onto the long-term memory system, which has unlimited space.⁹ Short-term memory has limited storage capacity, so being cognizant of this will improve learning effectiveness.¹⁰ The didactic coursework included in undergraduate and graduate athletic training programs may use multimedia presentations that are constructed in a way that could impede working memory storage capacity unnecessarily if the splitattention, redundancy, and modality effects are not taken into consideration.

With limited storage space in working memory, care needs to be taken in the complexity, quantity, and fashion in which information is presented to athletic training students in the classroom. Extraneous cognitive load refers to unnecessary information presented to learners as a result of ineffective instructional techniques.¹¹ Split-attention and redundancy effects are specific examples of multimedia conditions that increase extraneous cognitive load and should be avoided.¹² Having written titles identifying parts of a body located separately from the diagram and verbally explaining information being presented in writing without consideration of its timing or complexity and the student's level of competence are, respectively, examples of these effects. There is also the possibility of presenting information in a way that gives the working memory system the ability to expand its capacity. An increase in the space of working memory can be achieved by presenting modes of media that use both channel sources (audio and video) of the working memory system, termed the modality effect.¹¹ In other words, if 2 separate sources of information are needed for retention, a verbal explanation of a picture or diagram could increase the storage capacity of the working memory system. Storage space in the working memory of athletic training students can be manipulated using instructional strategies that promote efficiency and possibly an increase in storage space to maximize student learning.

The purpose of this article is to introduce strategies for athletic training educators using multiple modes to present material that will minimize space used with extraneous information and maximize the potential capacity of the working memory system by manipulating instructional media techniques, as suggested by the evidence. This article will explain and provide support for the split-attention, redundancy, and modality effects on learning and suggest how modes of media should be applied in the didactic component of the athletic training program to respect those effects.

SPLIT-ATTENTION EFFECT

A *split-attention effect* occurs when learners need 2 or more media sources of information to understand a concept and they are separated either physically or in time.¹¹ When multiple modes of media are used to present subject matter, placing them in close proximity to avoid searching and timing

them to allow for comprehension will improve learning effectiveness by lowering extraneous cognitive load.¹³

Research¹⁴ has used retention tests to measure a student's ability to store and retrieve factual information. The influence spatial proximity has on learning was explored in multiple studies.^{12,15–19} A study¹⁵ using first-year physical therapy students found that by physically integrating written text into figures there was a significant reduction in mental effort and improved retention of information compared to traditional photographs with written text referring to them. Consequently, when students are required to search for segments of written text and labels for pictures, a spilt-attention effect occurs, which increases cognitive load. An example of the split-attention effect and how to correct for it is provided with an anatomy illustration in Figure 1. This figure demonstrates how labeling anatomical features at the specific area, rather than requiring a search for the name, will reduce cognitive requirements that cause an unnecessary load to the working memory. Other college students of varying years were presented information in 3 formats, including integrated written text and illustration, separate written text and illustration, and written text in a pop-up window.¹⁶ Both integrated formats performed better than the separate text and illustration in terms of student retention. Also, the pop-up group outperformed the integrated written text and illustration group in retention. The authors suggested greater memorization with pop-up windows was due to less overall information to bog processing in the working memory. With a population of trade-school students, a color-coding format was implemented.¹² The strategy involved presenting a unique color in a specific segment of a diagram that corresponded with a written text explanation. The results demonstrated that students presented with color-coded segments of diagrams reported lower mental load ratings and higher retention. The authors cautioned that too many colors could, in themselves, create a significant load in working memory. Another population of college students were presented video animations with an "attention-guided" cueing strategy that consisted of zooming in on specific relevant information.¹⁷ The findings demonstrated a decrease in perceived difficulty of learning and higher problem-solving scores with zooming after several animation exposures. These results indicate that attention-guided cueing allows for the processing of complex information more effectively by freeing space in working memory. Another study¹⁸ exposed medical students to information on stroke conditions in 4 different formats, all consisting of browser-based learning and differing in level of cognitive and behavioral activity. The formats included observing a video that was learner-paced, sliding a handle below a model to move an embolus, clicking on vascular structures, and dragging the embolus along a path of arteries. The students presented with the movie and slider formats perceived the technology to be less difficult and also performed significantly better in transfer (ability to apply information in various contexts)¹⁴ tests. The complexity of technology for information presentation in the athletic training classroom must be taken into consideration to preserve cognitive capacity in the working memory of students, as space can be consumed via interpretation of complex technological instrumentation. For example, the purpose of an assignment may be to learn how the sensorimotor control system operates through the use of particular software. If the software is complex and loaded

attention effect.

Α



Figure 1. A, Causes split-attention effect. B, Reduces split-

В

with options, it may require time and technological skill to operate, which uses considerable space in working memory and is irrelevant to the intent of the assignment.

The pace at which material is presented can have an influence on student learning. The temporal effect on learning was introduced when college students of minimal prior knowledge were presented written text that explained pictures showing the structure of the human eye at varying speeds.¹⁹ Three groups were systems-paced (low, medium, and high presentation speeds), and one was learner-paced. Students who were self-paced reported the lowest mental effort and highest scores in retention. The students preferred choosing a pace that matched their comprehension, which improved processing of information and minimized extraneous cognitive load. The rate at which information is delivered to athletic training students through multimedia sources and freedom for them to self-pace can significantly influence cognitive load in the working memory and positively affect retention. For example, a blended classroom that supplies written material that can be reviewed by the athletic training students at their own pace is supplemented with a face-to-face component in which demonstrations of application, skill training, and assessments can be conducted.

To respect the split-attention effect and minimize extraneous cognitive load, written text and illustrations in athletic training classes should be visibly and timely presented in a specific manner. Written explanations that are located within figures (Figure 1) and cueing effects such as pop-up windows, color-coding, and zooming-in help to reduce an athletic training student's attention elsewhere. For example, a slide that emphasizes a concept by color-coding it in red or using bold text and underlining (Figure 2) helps direct athletic training students to specific concepts to minimize extraneous cognitive load. Technology offers an array of enticing presentation options for instructors; however, complex technological demands could add extraneous cognitive load to working memory unnecessarily. Students also prefer having control over the rate at which material is presented to retain

Figure 2. Cueing effects: Color-coding (red), underlining, and bold text. Abbreviation: ACL, anterior cruciate ligament.

ACL Injury Prevention

- 1. Sportsmetrics Program Jump-Landing Strategies:
 - A. Keep hips & knees sufficiently flexed
 - B. Keep knees over toes
 - C. Land with more weigh over forefoot
 - D. Avoid knee valgus

the information and minimize extraneous cognitive load. Consequently, written text in PowerPoint (Microsoft, Redmond, WA) or books may be learned most effectively on the student's own time.

REDUNDANCY EFFECT

The *redundancy effect* occurs when 2 or more modes of media are used to explain information, even though either source could have been used in isolation for a full understanding.¹¹ Information provided in one mode may explain a concept completely where an additional mode may or may not be needed, depending on the student's knowledge base. The redundant information contributes to extraneous cognitive load on the working memory. In research with novice apprentices, redundancy was demonstrated when a selfexplanatory diagram was used with written text to redescribe the diagram, resulting in a reduction in retention and transfer.²⁰ Another study²¹ discovered that when an audio explanation of a diagram was given to novice college students, an additional written explanation impaired learner retention and transfer, regardless of whether it was used concurrently or as a follow-up. Redundancy was also to blame when novice physical therapy students were presented diagram explanations only and they outperformed students receiving diagram and concurrent written text explanations in retention along with a significantly lower mental load rating.¹⁵ In order to efficiently use the limited space within working memory, caution should be exercised with information in athletic training when using multiple visual modes of media simultaneously that consist of the same information. For example, athletic training students being introduced to evaluation skills should not be presented with a picture of a special test and a written explanation concurrently (Figure 3). Optimally, in this case, a written explanation of the Lachman test for novice students to gain an understanding of how the technique is conducted before a visual representation is provided will minimize the load placed on the working memory.

Additional information that is not redundant but that is irrelevant to the subject matter could also unnecessarily occupy space in the working memory. When novice college students were exposed to an animation with a concurrent spoken text explanation along with an additional written text explanation, a redundancy effect occurred, which lowered Figure 3. The Lachman test is a special test used to determine the integrity of the anterior cruciate ligament (ACL) of the knee. With the patient in supine, the knee is flexed 20° to 30° . The athletic trainer grasps the patient's tibia with one hand and the thigh with the other. The tibia is quickly pulled anteriorly on the stabilized femur to assess the integrity of the ACL. An intact ACL would provide a firm endpoint. A positive Lachman test will demonstrate increased forward translation of the tibia and a soft end feel.



both retention and transfer.²² When interesting but irrelevant video clips were added, a further decrease in transfer was encountered.²² Consequently, caution should be exercised when sharing experiences with novice athletic training students that are not consistent with the subject matter at hand. Interestingly, high school students of higher prior knowledge levels given pictures and concurrent spoken text with some interesting but irrelevant information scored higher in retention and transfer than when irrelevant material was given in written text format.²³ The authors argue that additional interesting material that is spoken could assist in cognitive engagement for advanced students who have the ability to self-regulate and provide adequate cognitive resources for information of lower complexity. This evidence suggests that sharing interesting experiences that may not be "on task" could enhance learning with advanced athletic training students through engaging their attention.

Multimedia presentations often assist novice learners in both knowledge retention and transfer. However, if the additional explanatory information is used with advanced learners, it could act as a redundancy effect known as the expertise reversal effect.²⁴ A study²⁴ found that when instructional aides such as prompts, which ask questions or provide hints, were added to written text explanations to encourage a deep processing of information, student knowledge base had an influence in learning. These instructional aides provided a positive effect with novice and a negative effect with advanced college students in learning transfer.²⁴ A redundancy effect occurs with advanced learners as a result of an overlap between available knowledge and provided instructional guidance, which creates extraneous cognitive load.²⁵ In athletic training education, with advanced students it may be of greater benefit if only an illustration of a condition be provided and not a number of key features, hints, questions, or other additional information related to the condition. This emphasizes the importance of strategic instructional guidance in compliance with an athletic training student's level of

competence when presenting information using multiple modes of media. When using a visual presentation, additional visual information could impair learning with novice, and audio or visual with advanced students, by causing an expertise reversal effect. The addition of irrelevant material provided verbally could hinder learning for novice athletic training students, but if interesting, this material could benefit advanced athletic training students by sparing their interest.

MODALITY EFFECT

A modality effect occurs when 2 separate sources of information are needed to understand the content, which engages separate channels (auditory and visual) in working memory to increase its capacity.¹¹ For example, if a picture of a treatment technique were presented, a simultaneous audible explanation of how it is performed and why it would be effective for specific conditions is conducted. Theories developed by Baddeley²⁶ and Penny²⁷ provide the underpinnings for the modality effect. They both suggest that separate subsystems consisting of audio (spoken text) and visual (written text, pictures, and diagrams) allow an expansion of working memory capacity when both are used through multiple instructional modes.

Research^{28–32} has investigated the integrity of the modality effect. A study²⁸ using novice college students found that when they were presented with system-paced information in pictured form with brief concurrent spoken words rather than written text they increased in retention and transfer. Similar findings²⁹ occurred when high school students were presented graphics with concurrent spoken text at a learner pace. However, when novice college students were presented long, complex information in an audio format, they did not outperform the same information presented in audio with written text or simply written text formats in retention and transfer.³⁰ Therefore, with longer segments of information, simply using written text, whether learner-paced or systempaced, may be the most efficient method and may give athletic training students the opportunity to revisit complex conditions and allow for a more effective use of the presentation. The modality effect again occurred when novice trade apprentices were instructed by diagrams and concurrent brief spoken text, enabling them to outperform students with diagram only, diagram with written text, and diagram with written and spoken text in transfer.³¹ When material was presented in an animated form to novice college students with a concurrent or afterward-spoken explanation in short segments, they outperformed students given the same format in long segments in retention and transfer, further emphasizing the importance of brief verbal explanations.³² These studies are consistent with a modality effect using both visual and audio modes when the spoken explanation is limited in duration. There is a need for novice athletic training students to be exposed to multiple sources of media to understand concepts for the first time. Consequently, to optimize working memory storage capacity, when introducing a picture of a condition an instructor should also include an audio explanation. For example, a picture of a condition such as a patellar dislocation (Figure 4) could be presented. The instructor would concurrently provide a brief explanation of how dislocations generally occur laterally and how predisposing factors may include patella alta, patellar hypermobility, and lower extremity malalignment.

Figure 4. Laterally dislocated patella.



WORKING MEMORY CHANNELS

The timing of the modes of media and the channels they consume in working memory are areas of consideration in learning effectiveness. When novice college students were presented brief segments of information (16 sessions in 5 minutes) in a spoken with concurrent written text format, they outperformed information presented in audio-only format in terms of retention and transfer, demonstrating the use of separate channels.³³ However, when information was long in duration (350 words) and presented to technical apprentices in a concurrent spoken with text format, an audio-only format was significantly advantageous in learning retention.³⁴ This could be explained by the excessive cognitive load encountered by the working memory system with information of greater length and complexity.³⁴ Information that was spoken before a written text explanation of a diagram outperformed an audio with concurrent written explanation of a diagram in transfer using the same technical apprentices.³⁴ The need to present an explanation of a diagram with audio and text sequentially might be explained by the additional cognitive load incurred by the split-attention effect when using 2 visual modes concurrently, as with a diagram and written text.³³ Consequently, even when addressing separate channels in working memory (audio and visual), do so using short sessions of information concurrently in a segmented format and sequentially if multiple visual modes are implemented. When pictures were included with novice college students learning a language, the results³⁵ reflected higher retention scores when pictures and a spoken explanation were presented concurrently and greater picture recognition when pictures were presented after written text. Only provide a written text explanation before a picture if it is necessary for understanding and when caution is exercised to avoid a redundancy effect. A sequential presentation of 2 visual modes of media, such as a written text before a picture, may force students to pay equal attention to both and may result in retained recognition of the later.³⁵ If the goal is to provide an audio explanation of a picture, introduce both simultaneously, and

when picture recognition is desired, a nonredundant written explanation before the picture is acceptable. For example, when athletic training students are first learning clinical evaluations, if a picture of a special test or condition is presented, a brief audio explanation could be provided simultaneously. If the special test or condition is explained by written text, briefly explain the test verbally while the students are exposed to a nonredundant written explanation and follow up with a photo.

An animation or video with an audio explanation could be used to demonstrate a condition or functioning system, allowing for the acquisition of procedural knowledge. When supplementing a presentation with animation, an athletic training student's knowledge base may be a factor. With novice college students, presentation of a diagram with written text outperformed spoken text with animation in terms of retention and transfer.³⁶ However, another study³⁷ using novice college students found spoken text with animated agents outperformed both spoken and written text explanations of a visual representation of the cardiovascular system in retention. These results might be explained by experimental methodology. In the initial study,³⁶ the participants were psychology students receiving timed, computer-narrated animation to explain mechanical systems such as automobile braking, toilet operation, and lightning phenomena. In the study³⁷ in which animated agents assisted in retention, the participants were students taking educational technology courses receiving animation narrated by a human voice explaining function of the cardiovascular system at their own pace. The animation used arrows and gestures to maintain student attention to relevant information, with little entertainment to keep irrelevant information to a minimum. The differences in population, animation agent design, and subject matter result in different results in terms of retention. Another study³⁸ using advanced high school students found written explanations with animated prompts outperformed written explanations only in transfer, suggesting benefits for advanced learners. In addition, the voice of the agent was influential in learning when animation was presented with a human voice and it outperformed computer voice presentations in transfer.³⁹ A review of the literature suggested static presentation in the form of pictures or diagrams may be more advantageous for novice learners and dynamic animation for learners with greater subject matter knowledge.⁴⁰ For example, if animation is used to assist athletic training students in learning a special test, use a static picture and audio explanation with novice students or have a dynamic animation of the test without a verbal explanation for advanced learners. The success of using animation agents in athletic training programs may be dependent on multiple factors, such as the student's technological literacy, animation complexity, use of animation that minimizes irrelevant information, and use of cues to maintain attention. Other key factors include that the information being presented is at the learner's pace using a human voice and that it consists of nonvisible things that occur in life.

Under certain conditions, a *reverse modality effect* may occur. Novice college students given simple information, long in duration (>60 minutes) and at their own pace, were better off receiving it in written text concurrent with a diagram as opposed to spoken text with the diagram for retention and transfer.⁴¹ This study indicates that the quantity of information presented is a factor in the success of the modality effect. If a significant quantity of written text is required to explain multiple concepts or conditions with novice athletic training students, allowing them to read the information at their own pace without supplementing it with an audio explanation may be most beneficial to their learning.

An expansion in working memory storage space was suggested^{28–32} by engaging both the audio and visual channels of the working memory system. When visual information was reemphasized with a brief audio explanation, learning was enhanced. However, if the quantity of information was lengthy, visual presentation in written text only was warranted. Timing of an audio explanation should be simultaneous with pictures and can be concurrent with written text when both are simple, brief, and nonredundant. Static pictures and dynamic animation may be best for novice and advanced learners, respectively, and could depend on the animation agent design, material covered, and technological literacy of the student. A reverse modality effect occurs with novice students when learning is inhibited with material presented by both channels (audio and visual) when the information is long in duration.

In summary, since athletic training students do not demonstrate consistent learning styles^{5,6} and because healthcare students prefer multiple modes of presentation,^{2,3} it is imperative that educators introduce material in the didactic component of the process using a multimodal approach. The traditional application of multimedia presentations of subject matter can impede learning for athletic training students by neglecting the limited storage capacity of working memory. This article reviewed various effects that occur with multimedia presentations that either reduce space unnecessarily or potentially expand the capacity of the working memory system. Strategically manipulating instructional techniques in compliance with these effects will result in improved learning for athletic training students during the didactic component of an athletic training program.

Extraneous cognitive load can be minimized if respect is given to the split-attention and redundancy effects when using multiple modes of media to present information. The evidence with split-attention suggests integrating written text with static pictures or diagrams and the use of pop-ups, color coding, and zooming strategies to emphasize specific concepts. Also, care should be exercised when advanced technological approaches are presented, as they could demand higher levels of cognitive resources to interpret and administer, infringing on space needed in working memory. Working memory capacity dwindles unnecessarily when static pictures or diagrams are supplemented concurrently with redundant written text. Novice athletic training students may benefit from concurrent spoken explanations with static pictures or diagrams, where advanced learners may find this redundant. However, advanced athletic training students may discover spoken supplemental material that is irrelevant but interesting to be engaging and beneficial to learning, where it provides excessive processing for the novice learner.

Working memory capacity can be increased by utilizing the modality effect. The modality effect occurs with multimedia

Table. Multimode Strategies for Novice and Advanced Learners

	Visual Mode (Picture/Text)	Audio Mode	Timing of Modes (Concurrent/Sequential)
Novice	Picture Text (long or complex)	Audio (brief and relevant) or prompts ^a No	Concurrent
	Text (brief) Text (first) → picture	Audio (brief and relevant) or prompts ^a	Concurrent Sequential
Advanced	Picture Picture Text	Irrelevant but interesting No No	Concurrent
	Text No	Prompts ^b Audio	Concurrent

^a Questions, links.

^b Animation using a human voice.

presentations if the athletic training students are novice and the information is relatively short and segmented. When presenting the information in a spoken with concurrent picture or text format, the modes of media should be brief, segmented, and nonredundant. A reverse modality effect could occur if the information is lengthy, suggesting that one should not add an additional mode to complex written text and should allow the learner to be exposed to the lengthy written material at his own pace. If picture recognition is the goal, a nonredundant text explanation could be presented before the picture. Advanced athletic training students may benefit from animation agents that use a human voice more than do novices, who generally prefer a picture or diagram. A summary of multimedia presentation strategies using visual and audio modes and their timing for novice and advanced athletic training students is supplied in the Table in no specific order. This article was meant to provide evidence-supported instructional strategies using multiple modes of media for the didactic component of athletic training programs to improve learning effectiveness.

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