EDUCATIONAL RESOURCE

Volume 15 Issue 1 2023

DOI: 10.21315/eimj2023.15.1.9

ARTICLE INFO

Received: 28-05-2022
Accepted: 29-06-2022
Online: 31-03-2023

A Seven-Step Technique on PowerPoint Slide Preparation for Anatomy Lectures: A Cognitive Load Theory Approach

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To cite this article: Hadie @ Haji SNH, Asari MA, Kasim F, Mohd Yusof NA, Simok AA, Shamsuddin SA, Mohd Amin MSI, Mukhtar SF, Mohd Ismail ZI. A seven-step technique on PowerPoint slide preparation for anatomy lectures: a cognitive load theory approach. Education in Medicine Journal. 2023;15(1):113–121. https://doi.org/10.21315/eimj2023.15.1.9

To link to this article: https://doi.org/10.21315/eimj2023.15.1.9

ABSTRACT

Lecturing remains a main teaching method in anatomy education, despite being argued as ineffective in promoting understanding and higher-order cognitive skills. Designing and preparing anatomy lecture slides is a challenging task, as anatomy is a content-driven subject that involves complex three-dimensional diagrams. Overly wordy, overcrowded slides and poor organisation of text and pictorial materials are among the problems related to anatomy lecture slide preparation. These unorganised and problematic slides impose a high cognitive load on students and thus hinder learning. Hence, this paper elaborates on the strategies for lecture slide preparation that were formerly mentioned by the authors in a lecturing guideline known as the cognitive load theory lecture model. The strategies were organised into seven steps: (a) step 1: select plain background slides; (b) step 2: use headings and subheadings; (c) step 3: use visual cues and signals; (d) step 4: select a proper font type and size; (e) step 5: use text treatment; (f) step 6: choose a suitable colour scheme; and (g) step 7: synchronise all sub-elements. This paper also provides tested examples for each step to facilitate comprehension of the lecture content while applying the strategies.

Keywords: *Anatomy lecture, Cognitive load theory, PowerPoint slides, Extraneous load*

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INTRODUCTION

Lecturing is a common teaching method in higher education, although it is criticised for not being able to stimulate understanding and higher-order cognitive skills (1–2). Lecturing is described as a "sage on the stage" method, whereby the content is delivered didactically by a lecturer and students passively receive the information with limited interactions (3). Despite criticism of its effectiveness, many educators still conduct lecturing for their teaching, as it is practical and cost-effective (4). Indeed,

lecturing continued to be the main teaching method in many higher institutions during the COVID-19 pandemic, as it was feasible to be delivered through online platforms (5–6).

In anatomy curricula, lectures are used to provide anatomical input prior to cadaveric dissection or practical anatomy. The aim of anatomy lectures is to instil some prior knowledge and clinically applied knowledge before dissection and practical sessions (7). However, when lectures are delivered didactically by anatomists, it defeats the purpose of providing prior knowledge; rather, it induces a higher cognitive burden on students (8). Furthermore, anatomy knowledge is content-driven and is often perceived by students as a difficult subject (9). The intrinsic complexity of anatomy content contributes to an increase in cognitive load on learners, which consequently hampers learning if the instructional material is not properly designed and delivered (7).

The feasibility and utility of the lecture method has prompted many educators to come up with lecture guidelines and models (4, 8, 10–11). Although some of these guidelines are deemed effective by their developers, there is a lack of theoretical underpinnings in their principles and empirical evidence of the attainment of learning outcomes. Hence, it is uncertain how well these guidelines promote effective lecture delivery. Nevertheless, Hadie (12) have developed a lecturing guideline based on an instructional design theory—the cognitive load theory (CLT)—which eventually proved to have an impact on students' cognitive performance, load and engagement (7, 13). The CLT lecture model emphasises the use of CLT principles in reducing the total cognitive load of learners (7). The CLT principles are aligned with the three-stage information processing systems of the human mind, outlining three memory systems: sensory, working and long-term memories (14).

Information processing begins with sensory memory, which receives new information in the form of visual, auditory, olfactory, taste or tactile stimulus. This information is transferred to the working memory if the learner can consciously pay attention to one piece of information out of many sensory stimuli (15). Considering that the sensory memory has an ultrashort storage duration—it can only hold the information for less than one second—this information needs to be immediately transferred to the working memory before it decays (16). Hence, it is important to ensure that learners can direct their attention towards the instructional content during the learning process (17). Consequently, the transferred information is processed by the working memory into organised data, known as schema. Unfortunately, the processing and storage capacity of working memory are limited, as it can only receive a limited amount of information at one time, with an average retention time of 20 seconds (18). Therefore, the schema needs to be transferred to long-term memory before it decays. Once the schema is transferred to long-term memory, it is stored permanently as knowledge, and the learner is able to understand the learned information (19). These stored schemas—which indicate prior knowledge—can be retrieved back into the working memory to be incorporated with newly received information from the sensory memory for subsequent schema construction (20).

The CLT lecture model emphasises certain lecture slide preparation techniques that can produce organised and engaging slides. The lecture slide preparation techniques apply extraneous load principles that can reduce the unnecessary mental load of the learners: the modality effect, worked example effect, redundancy effect and split attention effect (12). The extraneous load is one of the cognitive loads imposed by distraction or unorganised instructional materials (21). The other types of cognitive load, the intrinsic load and germane load, are imposed by the difficulty level of the

instructional material and the amount of mental effort invested by the learners during learning, respectively (22–23). Learning is optimised when the total cognitive load does not exceed the learner's limited working memory capacity. Nevertheless, anatomy lecturers often face the difficulty of simplifying or presenting complex anatomical input on PowerPoint slides. For instance, a PowerPoint anatomy lecture slide could be overly wordy and overcrowded with textual and pictorial material. This condition can impose a higher extraneous load and hinder learning. Therefore, this paper aims to provide a working example of extraneous reducing techniques for slide preparation, as described in the CLT-based lecture model (12). The techniques were elaborated under seven categories, as follows.

SEVEN STEPS OF POWERPOINT SLIDE PREPARATION

When designing PowerPoint slides for anatomy lectures, it is important to ensure that the slides can direct learners' attention towards the instructional content. Hence, the preparation of PowerPoint slides requires several techniques that can reduce the extraneous load of learners. These can be achieved by applying seven steps of slide preparation that incorporate extraneous load reduction elements. The steps include the following:

a. Select plain background slides
b. Use headings and subheadings
c. Use visual cues and signals
d. Select a proper font type and size
e. Use text treatment (i.e. bolding, italicising, underlining and segmentation)
f. Choose a suitable colour scheme
g. Synchronise all sub-elements

Step 1: Select Plain Background Slides

Since anatomy content is often involved with complex diagrams, pictures and animations, selecting a plain slide background for anatomy lecture is a pertinent step to reduce distraction during the lecture session. A designed or themed slide background can hamper students' comprehension, as the slide may appear overcrowded, especially when an anatomy diagram is displayed. Given that anatomy diagrams are mostly coloured with many interacting elements, such as labels, the intrinsic load imposed by these diagrams during a lecture session is usually high. Therefore, a plain background is preferred for a formal anatomy PowerPoint presentation, as this can reduce the extraneous load and facilitate students' understanding. This strategy is aligned with the redundancy effect of the CLT that describes unoptimised learning when irrelevant input is concurrently presented with the actual instruction (24).

Selecting a plain white background slide is a wise option since white can suit black, blue or red letters as well as coloured diagrams. Furthermore, text bolding and italicising appear clearer on white background slides, especially in the printed version. However, the use of a white background in a physical lecture requires adequate lighting of the lecture hall and a well-maintained slide projector, which are negligible in online lectures. Likewise, dark-coloured slides (i.e. black, dark blue and dark red) are also suitable for anatomy lectures, provided that the colour of the fonts is suitable and the words are readable. For example, yellow and white letters suit a black background slide, while only the latter suit dark red and dark blue slides. Apart from that, when applying diagrams to the coloured background slides, the diagram should be framed on a white background to ensure an adequate contrast. In addition, florescent, highlighted coloured slides should be avoided, as they can be very bright and cause eye strain.

Figure 1(a) illustrates a white background slide with coloured letters and diagram, Figure 1(b) illustrates a dark background slide with white- and yellow-coloured letters. The coloured diagram is framed in a white background to increase the contrast; and Figure 1(c) illustrates a fluorescent, highlighted coloured background slide, which should be avoided.

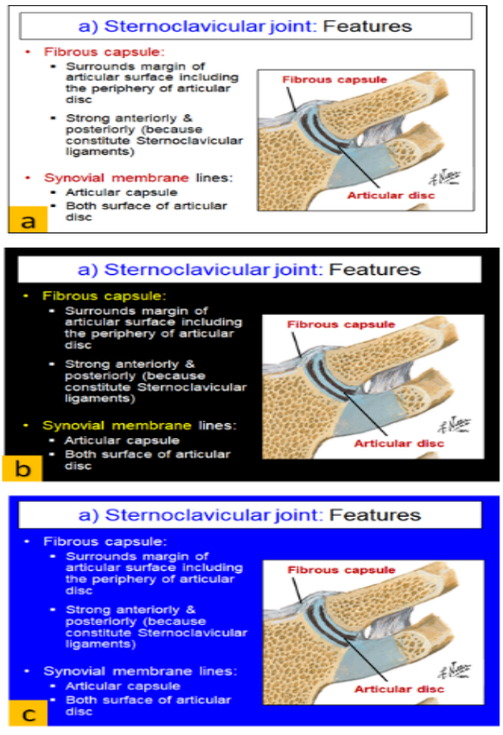

Figure 1: Different examples of plain background slides (12).

Step 2: Use Headings and Subheadings

To ensure an organised representation of instructional content, headings and subheadings should be utilised. Headings and subheadings direct learners' attention to one knowledge compartment at one time and thus provide adequate time for the learners' working memory to process the instructional content. This strategy is aligned with the isolated interacting element effect and segmenting principle of the CLT and cognitive theory of multimedia learning (CTML), respectively, that describe enhancement of learning when complex information is chunked into several small segments and are presented in learner-paced segments (25–26).

In general, the headings and subheadings of lecture content should align with the lecture outline. To ensure that students will be able to stay on track with the flow of the lecture, each heading is best displayed in a single slide on its own before the content slide and should be repeated at the beginning of each content slide together with its subheadings. It is important to ensure that the contents written on the slides reflect the displayed headings and subheadings. Figures 2(a) and 2(b) illustrate "heading and its subheadings" and the content slides, respectively.

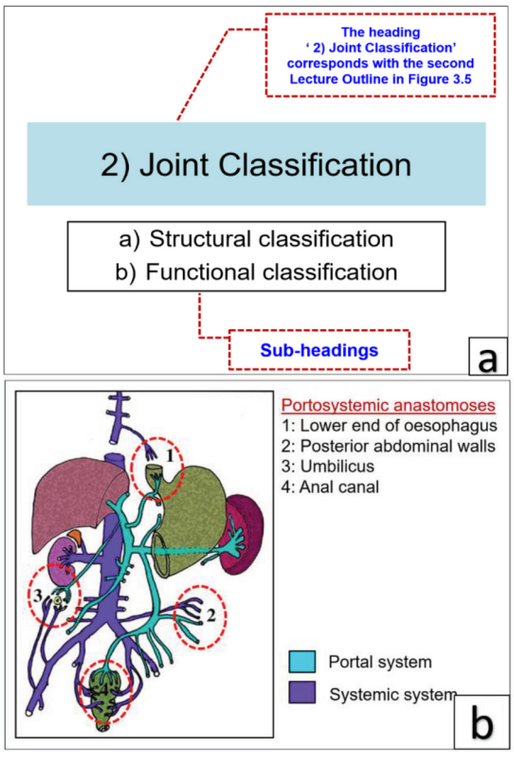

Figure 2: Heading, subheading and content slides (12). (a) A heading and subheading slide displaying the main heading and subheadings of the subsequent content; (b) A content slide that follows the heading and subheadings slide. The heading and the subheading are repeated at the beginning of this slide.

Step 3: Use Visual Cues and Signals

Incorporating visual cues and signals into PowerPoint slides can draw students' attention towards important information in text and diagrams. Appropriate cues and signals can enhance the understanding of complex content, as they reduce learners' visual searching during the lecture (27–28). The visual cues that can be incorporated in PowerPoint slides include arrows, circles, animation, dotted lines, and an animated flow diagram. The use of these visual cues should be properly planned to avoid element overcrowding on one slide, which could impose an extraneous load on students. Likewise, complex animations or animations that are not related to the instructional content should be avoided as these can distract learners' attention away from the actual learning material (29). When this happens, the cues will distract instead of guide students and thus hamper their learning. Figures 3(a) and 3(b) illustrate some examples of visual cues.

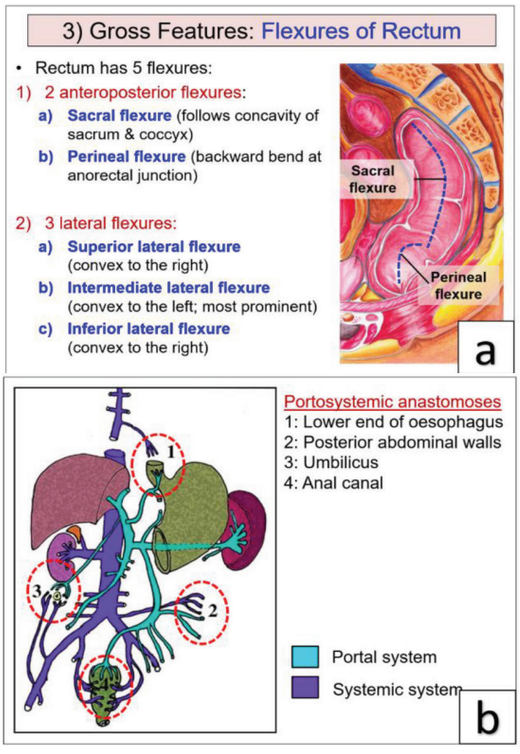

Figure 3: Examples of visual cues and signals (12). (a) Visual cues using dotted lines; (b) Visual cues using dotted circles.

Step 4: Select a Proper Font Type and Size

The use of appropriate font types and sizes can make PowerPoint slides effective. In general, fonts can be divided into two categories: Serif and Sans-serif fonts. In Serif font, the words contain small lines that tail out form the edges of the letters, such as in Times New Roman, Bookman Old Style, Cambria and Georgia font types. The words of Sans-serif fonts—such as in Arial, Calibri, Helvetica and Tahoma—do not contain the small line features, and thus can be clearly displayed as on-screen text. Therefore, Sans-serif font is more suitable for a PowerPoint presentation. To maintain the simplicity and consistency of the text, only one font type should be used throughout the lecture.

On the other hand, the selection of font size depends on several factors, namely the approach of the lecture—either online or face-to-face lecture—the venue of the physical lecture, the target audience and the size of the screen where the slides are projected. For a face-to-face lecture, the words should be readable by all students, especially those sitting at the back. Therefore, headings and subheadings can be written using at least a 30-point font size, whereas the text should contain no font smaller than 24 points. Figure 4 illustrates a PowerPoint slide that uses Arial font with an appropriate size.

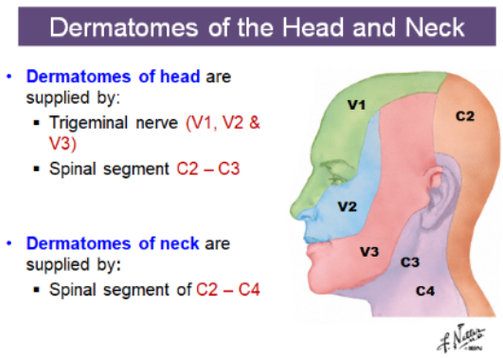

Figure 4: Arial font type was used, and the font sizes of the heading and text are 36 and 24, respectively (12).

Step 5: Use Text Treatments (Bolding, Italicising, Underlining and Segmentation)

To emphasise certain terminology or text, text treatments, such as bolding, italicising, underlining and segmentation, can be used as these treatments are aligned with the signaling principle of CTML. The signaling principle describes enhancement of learning when important instructional material are emphasised by adding cues that can highlight the organisation information (30). Text treatment grants different emphases and meanings to the displayed text. For instance, bold words appear darker than the surrounding text and thus indicate that they are being emphasised. Likewise, italicising and underlining can be used to emphasise certain words, nomenclature and terminology. On the other hand, text segmentation can avoid overcrowded slides, especially when diagrams are placed near the text. Segmented text shortens lengthy text, but the sentences should be complete and precise enough to elaborate on the subject matter. Despite these advantages, text treatment should be used with caution. When overused, these text treatments will lose their emphasising effect.

Step 6: Choose a Suitable Colour Scheme

Selecting appropriate colours for a PowerPoint presentation is a crucial step during slide preparation since colours influence the students' perceptions of the presented materials. Likewise, this strategy is also in line with the signaling principle of CTML as the use of appropriate colours can direct learners' attention towards important information (30). It is important to use colours that can differentiate the text and graphics from the background. For instance, dark-coloured text and graphics should be used in a white background slide, while light-coloured text and graphics should be used in a dark background slide.

Despite this, the colour combination of the text, graphics and background slides must not cause eye strain on the learners. Among the colour combinations that can cause eye strain and should be avoided are red and green, as shown in Figure 5(a): Green text on a red background (or vice versa) is difficult to read because the colours seem to blend together. This colour combination is not suitable for colour-blind learners; blue and red, as shown in Figure 5(b): The blue-and-red colour combination does not appear to have enough contrast when projected onto the screen; and orange and blue, as shown in Figure 5(c): The orange-and-blue combination seems to vibrate against each other. Vibrating colour combinations result in a vibrating illusion, which can strain the eyes.

In addition, the use of black and white colours should be avoided, as the slides will appear very dull. Although black text matches well with a plain white background, the text may seem under-emphasised, thus giving a false impression of the importance of the text. This can be overcome by highlighting some words or terms using different colours, preferably dark red and bright blue.

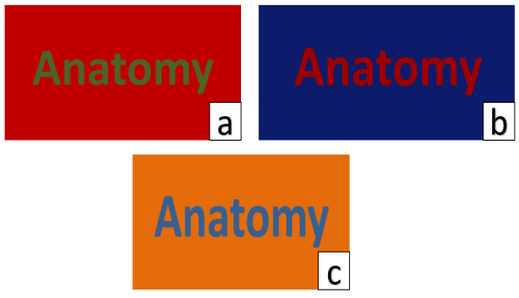

Figure 5: Examples of colour schemes that should be avoided (12).

Step 7: Synchronise All Sub-Elements

All the aforementioned techniques should be applied consistently to other slides within the lecture topic. This effort will help the students train their minds on how the information is being organised throughout the lecture delivery.

The seven steps of PowerPoint slide preparation are summarised in Table 1.

Table 1: The seven-steps of PowerPoint slides preparation based on the CLT

Step	Elements
Step 1: Select plain background slides	Use a plain slide background (either white or dark-coloured slides).
	Avoid theme designed or themed slide background.
Step 2: Use headings and subheadings	Display each heading in a single slide on its' own before the content slide.
	Repeat the heading and its related subheading, and at the beginning of each content slide.
Step 3: Use visual cues and signals	Use visual cues such as arrows, circles, animation, dotted lines, and animated flow diagram to draw students' attention towards instructional materials.
	The use of visual cues should be planned properly to avoid element overcrowding in one slide that can hampers learning.
Step 4: Select proper font type and size	Use Sans-serif rather than Serif font type in PowerPoint slides. Example of Sans-serif font are Arial, Calibri, Helvetica and Tahoma.
	Use at least 30 points font size headings and sub-headings, and no font smaller than 24 points for text.
Step 5: Use text treatment (bolding, italicising, underlining and segmentation)	Use bolding, italicising, underlining and segmentation to emphasised different weightage to the displayed text, and to shortened lengthy text or overcrowded slides.
	Text treatment should not be overused as these text treatments will lose their emphasising effect.
Step 6: Choose suitable colour scheme	Use colours that can differentiate the text and graphics from the background.
	Colour combination of the text, graphic and the background slide must not cause eye strain to the learners.
	Avoid using black and white colours only as the slide will appear very dull.
Step 7: Synchronise all sub-elements	Techniques in the Step 1 to Step 6 be consistently applied to other slides within the lecture topic.

CONCLUSION

Designing and preparing PowerPoint slides are important elements in anatomy lectures, since well-constructed PowerPoint slides are a prerequisite to facilitate students' understanding of the lecture content. Given that lecture delivery is still being practiced—either through face-to-face or online approaches—and anatomy lectures are often taught using two-dimensional diagrams of figures, the skill of preparing a PowerPoint presentation is required to stimulate 3D visualisation and mental imagery of anatomical structures. The aforementioned steps were designed based on the CLT principles, by which the techniques introduced were related to the reduction of extraneous load. By complying with this guideline, educators are eliminating distractions that could be imposed by unorganised and overcrowded slides. The reduction of an extraneous load would allow students to reserve mental effort for processing relevant instructional material rather than distraction. Indeed, the seven steps of slide preparation introduced in this paper are simple, practical and doable. If they are properly applied, students should be able to appreciate anatomy content taught through lectures.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Muhamad Nor Firdaus Ab Rahman and Madam Norhana Arshad, Medical Laboratory Technologists from the Department of Anatomy, School of Medical Sciences, Universiti Sains Malaysia for their contributions in drawing the diagrams that are reported in this paper. This work was supported by the Universiti Sains Malaysia Research University under Grant number [1001/PPSP/8016121].

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