Original Article

Evaluation of Design Quality of Online Biochemistry Animations Using Mayer's Principles

Ravi Kishore Polepalli[1]

Authors' affiliation: [1]Professor, Dept. of Biochemistry, MVJ Medical College and Research Hospital, Hoskote Taluk, Bengaluru Rural District
Correspondence: Dr. Ravi Kishore Polepalli, Email: writekishore@yahoo.co.in, Mobile No.: 9980663298

ABSTRACT

Introduction: Online animations are accessed by MBBS I[st] year students in order to learn complex concepts in Biochemistry. Multimedia learning principles proposed by Richard E Mayer, have been used in the design of animations to enhance learning. There is a paucity studies that have evaluated the design of animations in Biochemistry based on multimedia learning principles. In this study, our aim was to evaluate the design quality of online animations in Biochemistry using a framework based on Mayer's multimedia learning Principles.

Materials and Methods: A total of 102 animations belonging to various topics in Biochemistry (MBBS I[st] year Syllabus) were shortlisted through online search using www.google.com and www.youtube.com. These animations were evaluated using a framework based approach devised using Mayer's multimedia learning principles. Animations were scored based on their compliance with multimedia learning principles.

Results: The shortlisted animations had median score of 8 (Interquartile range =1) out of a maximum score of 10. None of the animations had a score of 10 (100%). Personalization principle was violated in 96.1 % of animations.

Conclusions: Online animations in Biochemistry do not comply with all of the Mayer's multimedia learning principles and hence their effectiveness as learning aids for I[st] MBBS students may be reduced. To increase their effectiveness, the design quality of online Biochemistry animations may be enhanced by incorporating all the multimedia learning principles during the development stage.

Keywords: MBBS students, Medical students, Mayer's principles

INTRODUCTION

Richard E Mayer, a pioneer in multimedia learning research, proposed multimedia learning principles that have been used to design animations to maximise learning.[1,2,3] MBBS I[st] year students access online animations to learn complex concepts in Biochemistry, that in turn helps them understand the rationale behind the pathophysiology and management of diseases.[4] However, there is a paucity of studies that have evaluated online animations in Biochemistry to determine whether they could serve as effective learning aids. Our objective was to evaluate the design quality of online animations in Biochemistry using a framework based on Mayer's multimedia learning principles.

METHODS

In this cross-sectional study, online animations related to Biochemistry topics were evaluated at one point of time. Ethical approval was not required for this study as human subjects were not included in this study and all the data (animations) used in this study can be publically accessed online for free. Our study sample included 102 online animations in Biochemistry.

MBBS I[st] year syllabus as prescribed by National Medical Commission (NMC) of India in the year 2019 was reviewed and 27 Biochemistry topics were chosen.[5] Animations relevant to these topics were searched on search engines www.google.com and www.youtube.com using appropriate key words. Date of access of animations was July 24[th] and 25[th], 2021. In the context of our study, an Animation was defined as follows- "Animation refers to a simulated motion picture depicting movement of drawn or simulated objects".[3] Inclusion criteria for the animation to be shortlisted were-1. Animation should fit the above definition. 2. Animation should have content relevant to the topic. Animations that require payment or that require user credentials for access were excluded from the study. A total of 102 animations were shortlisted using the above inclusion and exclusion criteria.

Framework Based Approach for Analysis of Online Animations: We used a framework based on multimedia learning principles to analyse the design quality of online animations in Biochemistry.

Multimedia Learning Principles: Richard E Mayer, a pioneer in multimedia learning research, proposed multimedia learning principles, based on cognitive theory of multimedia learning. These are evidence based guidelines that could be incorporated to improve the design quality of multimedia like animations to improve learning outcomes. Mayer proposed 12 principles-.

1) Coherence Principle: It states that users learn better when extraneous words, pictures and sounds are excluded in the multimedia presentation rather than included..

2) Signaling Principle: It states users learn better when essential words/graphics are highlighted through cues in a multimedia presentation.

3) Redundancy Principle: It states that users learn better when graphics and narration are used in multimedia presentation rather than graphics, narration and on-screen text.

4) Spatial Contiguity Principle: It states that users learn better when corresponding words and pictures are presented in proximity rather than far from each other on the screen in a multimedia presentation.

5) Temporal Contiguity Principle: It states that better learning outcomes could be seen when corresponding words and graphics are presented simultaneously rather than successively.

6) Pre-training Principle: Learning is better from a multimedia presentation if users know names and characteristics of concepts/components beforehand.

7) Modality Principle: Learning is better through a multimedia presentation that uses graphics and narration rather than graphics and on-screen text.

8) Personalization Principle: It states that words used in the multimedia presentation should be in conversational style rather than formal style for better learning outcomes.

9) Image Principle: It states that there no evidence to show that speakers image on the screen would improve learning outcomes.

10) Multimedia principle: It states that learning is better through words and pictures in a multimedia presentation than words alone.

11) Voice Principle: Learning is better when the narration in a multimedia presentation is in a friendly human voice rather than a machine voice.

12) Segmenting Principle: Learning outcomes are better when the multimedia presentation is broken down into user-paced segments rather than as a continuous unit.

Voice principle was not applied used in this study more evidence is needed to support it's use. Segmenting principle was not included as the users on online animations may pause/play the animations as convenient and thereby benefit from natural application of this principle during their routine use.[1]

These principles when incorporated in the design of multimedia presentation like animations have been shown to reduce extraneous processing, manage essential processing and enhance generative processing, thus contributing to improved learning outcomes.[1,3,6,7,8]

Extraneous Processing, Essential processing and Generative Processing:

a) Extraneous processing: It is a type of cognitive processing that that does not serve instructional goal. It is due to the presence of extraneous material (irrelevant images, spoken words) in the animation. Presence of extraneous content in the animation diverts all or major portion of the cognitive capacity towards attending to extraneous material and the learner is left with insufficient cognitive capacity to learn intended content. Coherence, Signaling, Spatial contiguity, Temporal Contiguity and Redundancy principle may be incorporated in the design of animation to minimize extraneous processing.

b) Essential processing: Essential processing is a type of cognitive processing which involves selecting essential content (images and words) in the animation and representing them in working memory. It is precursor to deeper understanding of the presented content. It is caused due to complexity of material in animations. Animations that are complex may divert all or major part of cognitive capacity towards essential processing and learners are left with insufficient capacity to organise and integrate the presented information in the animation, required for deeper learning. Segmenting, Pre-training and Modality principles have been proposed to manage essential processing.

c) Generative Processing: It is a type of cognitive processing required for deeper understanding of presented topic. It involves organizing the presented information i.e. images into coherent "image" model and spoken words into "spoken words (words)" model, integrating both the models to form an "image-word" model and integrating this combined model with previous knowledge. It is attributed to the motivation of the learner. Personalization, Multimedia, Voice and Image principles have been shown to foster generative processing. In other words, they elicit social response of the learner which motivates the learner to put extra effort to organize and integrate presented content that leads to deeper learning.[1,3]

In summary, an animation's design quality may be enhanced if it is designed in a way consistent with multimedia learning principles which in turn helps the learner to select, organize and integrate the presented images/ words into coherent mental models that in turn leads to deeper learning of presented concepts.[1,3]

Scoring of Animations: The shortlisted animations (n=102) were evaluated using 10 of the Mayer's multimedia Learning Principles. Voice and segmenting principles were not used as discussed before. If a principle was complied with in an animation, a score of 1 was given. If a principle was violated, a score of 0 was given. Maximum score for an animation was 10. Aggregate (total) score for an animation was obtained after adding all the scores for individual principles. Hence, an animation with higher score indicates higher the compliance with multimedia learning principles, and learner is expected to show better learning outcomes, as compared to the ones with lower scores.

Statistics: Descriptive statistics were used in the form of proportions and ranges.

RESULTS

The shortlisted 102 animations had a median score of 8 (Inter-Quartile Range = 1) out of a maximum score of 10. Personalization and Pre-training principles was violated in 96.1% and 84.3% of the animations, respectively. In contrast, Image and multimedia principles were complied with in all the animations (Table 1).

None of the animations complied with all the multimedia learning principles. Majority (82%) of the animations had a score between 7-9. In contrast, minority of them (18%) had scores between 4-6 (Table 2).

Table 1. Distribution of animations based on compliance/violation of individual multimedia learning principles

Name of Principle	Animations complying with each principle (%)	Animations violating each principle (%)
Coherence	91(89.2)	11 (10.8)
Signaling	87 (85)	15 (15)
Redundancy	85 (83.3)	17 (16.7)
Spatial Contiguity	86 (84.4)	16 (15.7)
Temporal Contiguity	87 (85.3)	15 (14.7)
Pre-training	16 (15.7)	86 (84.3)
Modality	96 (94.1)	6 (5.9)
Personalization	4 (3.9)	98(96.1)
Image	102 (100)	0
multimedia	102 (100)	0

Table 2. Distribution of animations based on scoring using multimedia learning principles

Number of Animations (%)	Scoring of animations using multimedia Learning Principles (Max score=10)
Nil	1 - 3
19 (18)	4 -6
83 (82)	7-9
Nil	10

DISCUSSION

In this study we evaluated the design quality of online animations in Biochemistry using a framework based on Mayer's multimedia learning principles.[1] None of the animations complied with all the principles of multimedia Learning. Personalization principle was violated in 96.1% of the animations. Due to lack of a conversational style of narration, learners using these animations may not be motivated enough to organise and integrate the presented information in working memory, impacting deeper learning of concepts. Pre-training principle was violated in 84.3% of animations suggesting that learners using these animations may be overwhelmed by the complexity of animation content and may fail to select essential content for creating a coherent mental model of images and words. Majority of the animations did not comply with Personalization and Pre-training principles. Learners that use such animations that violate both the above principles may have challenges in selecting , organising and integrating information presented in the animation, resulting poor learning outcomes. Multimedia principle and image principle was complied with in all the animations. Other principles were violated to a greatly lesser extent (5.9-16.7%).[1,3]

We did not find any "ideal" online animation online in Biochemistry in our study, i.e. one that complies with all the multimedia learning principles. Majority (82%) of them had scores in the range of 7-9 indicating that these animations may not have complied with 1-3 animations each. In contrast, only 18% of animations had scores between 4-6 indicating that these animations would not have complied with 4-6 principles. An animation not complying with multiple multimedia learning principles may have cumulative adverse consequences on learning outcomes. These consequences may depend on – a. number of principles violated in animation, b. degree of violation of individual principle in an animation, c. type of principles violated (ex. whether all the violated principles reduce extraneous processing or whether they manage extraneous, essential and generative processing) in an animation.

For instance, a particular principle may violate Coherence principle, Modality and Personalization principle. Violation of Coherence principle may lead learner engaging in extraneous content (distracting elements like irrelevant pictures, words) that does not serve instructional objective.[7] Noncompliance with modality principle may lead essential processing overload suggesting that learner may face challenges in selecting essential content (images and words) in the animation to build mental models for images and words in working memory. Violation of Personalization principle results in underutilization of generative processing as the learner is not motivated enough to organize and integrate the presented information to create combined mental "image-word" model and integrated combined "image-word" model with previous knowledge. Such an animation would impact learning process at multiple levels affecting the selection, organisation and integration of presented images and words in working memory leading to poor learning outcomes. On the contrary, if an animation violates 3 principles that manage extraneous processing, cumulative adverse effects on learning outcomes may be different.[1]

Our study had certain strengths. We used a framework-based approach to analyse the design quality of online animations in Biochemistry in order to assess their potential as learning aids. Our framework was based on evidence-based multimedia learning principles. Animations included in our study were from diverse range of topics in Biochemistry. These topics were chosen from Biochemistry syllabus of Ist year MBBS and thus the animations evaluated are relevant to MBBS students. We used two most popular search engines (www.google.com and www.youtube.com) and hence this study would be representative of the way learners access animations in real life.[9]

Our study had a few limitations that need to be considered. Generally, these principles (findings) are more strongly applicable when the topic is complex, pacing of the animation is fast and learners have low prior knowledge of topic.[1] Though we included 102 animations in our study from diverse topics in Biochemistry, future studies with larger sample sizes would be required to ensure generalizability of findings, given the size of online platforms such as www.google.com and www.youtube.com.

Experimental Studies on animations may be done to assess the cumulative effects of violations of multiple multimedia learning principles on learning outcomes.

CONCLUSION

None of online animations in Biochemistry that we accessed complied with all the Mayer's multimedia learning principles. Consequently, MBBS students using these animations may face challenges in selecting, organizing and integrating the images and words to create coherent mental models that promote deeper learning. Medical organisations, publishing companies and individuals that create animations could enhance design quality of Biochemistry animations by incorporating all the multimedia learning principles during the design stage, to enhance their learning potential.

REFERENCES

1. Mayer RE. Multimedia Learning. 2nd edition. Cambridge: Cambridge University Press; 2009.
2. O'Day HD. Animated Cell Biology: A Quick and Easy Method for Making Effective, High-Quality Teaching Animations. CBE—Life Sci Educ 2006; 5: 255-63.
3. Mayer RE, Moreno R. Animations as an aid to multimedia Learning. Educational Psychology Review 2002; 14 (1):87-98.
4. Ravi Kishore P, Keshavamurthy HR. Patterns of Internet use and their implications in Indian Medical students: A study from a south Indian Medical College. Journal of Evidence Based Medicine and Healthcare 2016; 3(36): 1779-83.
5. Supe A, Sheshadri GK, Singh P, Sajith KR, Chalam PV, Maulik KS, et al. Medical Council of India, Competency based Undergraduate curriculum for the Indian Medical Graduate. 1st ed. New Delhi: Medical Council of India; 2018. Volume 1.
6. Mayer RE. Applying the science of learning to Medical education. Med Edu 2010; 44(6):543-9.
7. Mayer RE, Heiser J, Lonn S. Cognitive constraints on multimedia learning: When presenting more material results in less understanding 2001; 93(1):187-98.
8. Mayer RE, Fiorella L. The Cambridge handbook of multimedia learning. 3rd edition. Cambridge: Cambridge University Press; 2021.
9. Davies D. Meet the 7 Most Popular Search Engines in the World [Internet]. Beginner's Guide to SEO. 2021 [cited 4 December 2021]. Available from: https://www.searchenginejournal.com/seo-guide/meet-search-engines/#close